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THE MANUFACTURE OF WALL PAPER [see page 184]

The Naval Forces of Old Poland

Additional Facts About the Naval Forces of Poland in 1863, During the Revolution Against Russia

By Z. Komorowski

If we glance at an ethnographical map of the times of Charlemagne, we will see that of all the Slavish peoples only the following had access to the sea: in the South the Serbs and Croats and in the North, first the Pomeranians of the Lech Tribe, and then the Wellettes or Lutatians and finally the Obotrites.

According to the legend, the first attacks of the Pomeranians against the Danish fleet in the Baltic Sea took place during the reign of Prince Wizymir. Later on we see the fleet of the Lutatians and Obotrites waging naval warfare against the Danes and Saxons, that is, against Germanic tribes. The Pomeranians often renewed their attacks against the German city of Lubeck, burning the same. At the time of the creation of a national State in the Polish territories, as they lacked a free access to the sea, the Poles turned their glances toward the Pomeranian lines with the purpose of annexing them by diplomatic means, or if necessary, by force of arms. It is, however, very difficult to place the origin of the first war declared by Wladyslaw Herman in 1091 against the Pomeranians. It is exceedingly probable that the cause of this war was the mastery of the coast. The war was favorable to the Poles, but, however, the King was not able completely to subdue the Pomeranians.

His son, Boleslaw, called the Wry Mouth—who by his marriage in 1102 with the Princess Cbislawn, a daughter of Swiatopolk II, Prince of Kiew, gained security of the kingdom on the Russian frontier, threw his entire force against the Pomeranians, who were beginning to shake off the domination of the Poles. Boleslaw understood that the submission of the Pomeranians was of vital interest, not only on account of the racial consanguinity, but mostly on account of the geographical position of their land. The only commercial highways available to Poland at that time were those of the Vistula and of the Oder. In order to extend its commerce, it was absolutely necessary to seize nearer sea routes. Following this idea, Boleslaw III did not hesitate in attacking his neighbors. The war lasted for several years, success attending the Polish Arms, in such a way, that even the Island of Rugen was taken, and Boleslaw vanquished the Pomeranian troops near Nakio, in 1109.

Polish domination over Pomerania was thus assured. The administration of the conquered land was entrusted by Boleslaw to his father-in-law Swiatopolk.

The historian Miklaszewski, relates how the Island of Rugen was taken by the Poles, in the following ways: The Pomeranian Prince, Swiencibor of Warcislaw had been taken prisoner by his own subjects, who had revolted against him. Upon his request, Boleslaw came to his aid and liberated him. Swiencibor put himself under the protection of Poland, and in 1118 with all his people embraced Christianity. Boleslaw made great efforts to expand Christianity in Pomerania. In the course of the war, which afterwards ensued between the Poles and the Pomeranians, Boleslaw vanquished the enemy and at the head of his victorious troops, crossed the River Oder, and after vanquishing the Lutatians, landed on the Island of Rugen, of which he took possession after a short and decisive battle. Afterwards he invaded the territory inhabited by the Wimilys, the Helvetes and the Obotrites, everywhere carrying the terror of his warlike deeds. In the course of his expeditions, Boleslaw reconciled himself with the banished King Nicolas and his son Magnus married the daughter of Nicolas. Certain historians claim that the conquests of Boleslaw made such an impression upon the neighboring countries that the Danes offered him their crown, which he, however, refused.

Notwithstanding the triumphs of their arms and the possession of Pomerania, the Polish Government entirely neglected the organization of their naval forces, and contented themselves with the safeguard of the free circulation of their merchant marine.

However, the Pomeranians in spite of their great losses in manpower and material, did not give up their fight for freedom. Their several efforts were directed towards the realization of this aspiration, but Leszek I, the White, knew how to counteract these movements, and after having re-established his rule with fire and sword, named Swiatopolk as his Governor. This latter, in spite of all the favors of which he was a recipient, showed himself very ungrateful towards Leszek. In his aspirations to make himself independent ruler of Pomerania, he did not even recoil from participating in a plot against the life of Leszek. The historian, Blugosz, tells us that Swiatopolk liked to boast of his military forces, not only on land but also on sea.

In another chapter, Blugosz recounts how Warcislaw, Prince of the Kaschubes, was warring upon Swiatopolk of Pomerania, and in the year 1259 approached with his vessels, the city of Siup. In 1309 during the reign of Wladyslaw Lokietek (the Short), the Knights of the Cross took the city of Gdansk, and since then for a century and a half, Poland has been deprived of access to the sea.

In 1410, Wladyslaw Jagiello, King of Poland, and Grand Duke of Lithuania, completely defeated the Knights of the Cross in the battle of Tannenberg, near Grunwald, but notwithstanding it was not given to the Poles to gain a foothold upon the coast. Half a centry later a new war broke out, in 1462, and the Poles again defeated the Knights of the Cross near Putzk. In this war the Poles were fighting both on land and on the sea. Not having proper vessels, the Poles requisitioned the fleet of Gdansk and fitted them up to meet the enemy.

In 1463, about a mile off the City of Elblong, a naval combat took place between the Poles and the Knights of the Cross, in which the latter lost in killed 1,000 men and the Poles captured several vessels with 600 sailors. The Knights of the Cross now addressed themselves to the Livonian Knights, asking for help. Their request was granted, and the Livonian Knights joined the Knights of the Cross, but the Poles, with the aid of the inhabitants of the City of Elblong, completely destroyed their fleet. The historian, Gzacki, says that in memory of these naval victories of the Poles, King Kazimir Jagiellonczyk recompensed the City of Gdansk by granting her the title of "Polish Admiral." Later on, the Polish Hetmans, commanding the naval forces, bore the title of Admiral. In 1466 the well-known treaty was concluded at Torun. The principal points were the following: A certain part of Prussia, known as "Royal Prussia," remains in possession of the Poles, and the eastern part of Prussia belongs to the Knights of the Cross with the condition, however, that Poland maintain its sovereignty over the Knights of the Cross as its vassals. Besides, the Grand Master of the Order was obliged to accept the ceremonial, according to which he had to kneel before the King of Poland, and be present at the Sessions of the Supreme Council of the Polish Republic. All the Knights of the Cross were regarded as being under the protectorate of Poland.

At the time, Poland has regained access to the sea, and made use of the fleet of Gdansk. During the reign of Sigismund the Old, Albrecht of Brandenburg, elected Grand Master of the Order of the Knights of the Cross, refused to give to the King of Poland the homage stipulated in the treaty of Torun. To get satisfaction, a fleet from Gdansk, composed of five vessels, attacked the City of Memel, and completely burned the same to the ground. The Polish fleet then rushed to the encounter of the German ships that were coming to the aid of the Knights of the Cross and sank them all. The Knights of the Cross were obliged to conclude peace with Poland. It was on the tenth day of April, 1525, that Albrecht, as Prussian vassal Prince (the title of Prussian Prince was reserved for the Polish King) swore publicly at Cracow the solemn oath of fealty in the presence of the King of Poland.

Furstenberg, the Grand Master of the Livonian Order, in becoming a Lutheran, got into trouble with the Archbishop of Riga (a nephew of the King of Poland, Sigismund August) confiscated his domains and threw him into prison. Sigismund August upon learning of this, sent an embassy to Furstenberg demanding the immediate release of the Archbishop. The Grand Master not only did not accede to these demands, but put the Ambassador to death. Therefore, King Sigismund determined to declare war against the Livonians. The war, however, could have brought favorable results to the Poles, only in the case of the participation of a strong naval fleet. The ships of Gdansk, above mentioned, were not sufficient. To remedy these drawbacks, the King took measures to create in the Baltic Sea a Royal Naval Fleet. First, there were three vessels flying the Royal Polish Ensign, then nine more were built, then three more, and finally the Prince of Krolewiec, Vassal Prince of Poland, put at the disposition of the King, the necessary funds for the construction of three more ships. So that the naval fleet of the Polish Kingdom was composed of eighteen vessels, and was considered for those times as very strong. The displacements of these ships varied between 16 and 200 lasts (30 to 360 tons) and the capacity between 1,800 and 6,000 kortses (216,000 to 720,000 liters). The largest units were armed with 30 cannons. Hauer writes, that besides the large vessels, there were also smaller ones which participated in the battle. The King had named Thomas Serpinek as Admiral and John Kostka, Castellan of Gdansk and Under-Treasurer of Prussia, was named President of the Marine (Secretary of the Navy). Not only Poles were accepted as sailors, but also Kashoubes, who, as inhabitants of the coast were considered excellent seamen.

The mighty Polish Fleet was not without danger for its neighbors. The English Queen, Elizabeth, the King of Denmark and the Lubecker, often complained of the high-handed proceedings of the Polish High Sea Fleet. They reproached it with halting merchant vessels. On board these vessels, the Poles found arms and ammunition destined for the Livonian Knights and the Muscovite Czar Ivan IV, both sworn enemies of the Republic. To the complaints of the interested parties, the King of Poland invariably answered: "I have the right to deprive my enemies of the means of augmenting their forces." The inhabitants of Gdansk were also not satisfied with the Polish Fleet as it happened that Admiral Serpinek confiscated merchant vessels to press them into the service of the naval forces. He justified these measures by his suspicious of treason on the part of the inhabitants of Gdansk, but the King always ordered the restitution of the ships.

Once the Gdansker merchants arrested eleven drunken sailors who were making a row in the streets and killed them. The representatives of the City of Gdansk appeared on the 23rd of July, 1571, before the King, and on their knees humbly asked pardon for these misdeeds. The King pardoned them. In view of the naval might of Poland, the Hansa cities especially Hamburg, Lubeck, Bremen, etc., asked King Sigismund August to be their protector.

In spite of the favorable issue of the War with Livonia, Sigismund August dissolved the fleet. After his [illegible] Henry of Valois was elected King of Poland under the condition to build a naval fleet and to unite the port and the city of Narva with the Polish Crown. As the reign of this king lasted only five months, the people did not see these promises fulfilled. His successor, Stephen Batory who waged war exclusively on land, could not devote himself to the real organization of the fleet. However, there exists a historic document dated 1577, and signed by Stephen Batory during the revolt of the Gdanskers, which we herewith reproduce: "We herewith make known to whom this may concern, to our subjects as well as to strangers, that in order effectively to put into life our measures against the Gdanskers, the building of a naval fleet is absolutely necessary. We have, therefore, ordered Peter Kluczewski, Starosta of Malogoj, our Secretary, as well as the Mayor and the Municipal Councillors of our City of Elblong, to organize our naval fleet and ordered them as follows: 'Not desiring that our sailors be regarded as pirates, we herewith order that they should be deprived of the right of capture of vessels with the exception of those of Gdansk. On the contrary, we order them to help in every circumstance the vessels and forces of his Majesty, the King of Sweden and his subjects, and of the Hansa Cities. Our vessels should only capture and destroy the fleet of Gdansk, of which I make you herewith a present. Outside of this profit we pledge ourselves to pay to our sailors a wage, the amount of which will be fixed by His Excellency, the Starosta of Malogoj, and which wages shall be regularly paid to you. We herewith promise to pay accordingly to the treaty concluded by His Excellency Kluczewski, any damages arising to the proprietors of the vessels which should be utilized in our Naval warfare. Moreover, we promise to these owners the remittance of the custom duties. Given at our Headquarters near Gdansk, the 28th day of July in the year of our Lord fifteen hundred and fifty-seven. Stephen Batory.'"

On the same day Stephen Batory gave orders to Kluczewski to arm and equip the ships.

Sigismund the III, not only ordered ships built, but also ordered that the military training of the sailors be of the highest. The professors of the artillery school were commanded to teach not only the art of artillery land, but also that of the sea. John Chodkiewicz, who had received the title of Admiral during the war with

Livonia, gained many victories by land and sea. In 1609 he conquered Dunamunde and Parnava and captured two vessels from the Swedes. After having enlarged his fleet by several vessels bought from the English and the Hollanders, Chodkiewicz gave battle to the Swedes in the Baltic sea, not far from the City of Chak (Szaki), and defeated them. His successor was the Admiral Cippelmann, who had under his orders nine ships built by Sigismund the III. The 28th of November, 1627, a battle royal before Danzig was given to the Swedish fleet composed of eleven vessels under the command of Nicolas Hogenskjold. The Poles attacked the enemy with nine vessels and were completely victorious. Admiral Hogenskjold died at his post; a panic occurred among the sailors who blew up several of their own vessels; two ships fell into the hands of the Poles; some of the Swedes took flight and took refuge in the City of Pilawa.

Two years later a minor engagement took place between the same adversaries. The Poles captured a Swedish vessel and brought it into Gdansk. The success of the Polish fleet strongly impressed the statesmen of Europe. The Spanish conceived the idea of using our ships for their political aspirations. Their diplomats even were able to determine King Sigismund the III to send a fleet to Wismar to aid Emperor Ferdinand the II against Denmark. In exchange for this collaboration, the Spanish promised to help Sigismund in his efforts to obtain the Swedish Crown. This treaty being discovered, Denmark united its fleet with that of Sweden and attacked the Polish fleet. Several vessels and 120 Polish cannons fell into the hands of the Swedes, notwithstanding their heroic defense under the command of Christopher Arciszewski, whose high qualities as an Admiral had been everywhere appreciated, even in Holland and in America.

As a curiosity we reproduce herewith information concerning the salaries of the highest dignitaries: The Crown High Hetman received only 1,800 Polish florins yearly (about 1,125 francs). The Admirals 6,000 Polish florins (about 3,750 francs). Arciszewski received 9,000 (about 5,625 francs) but he exercised other functions besides those of Admiral.

King Wladyslaw the IV, resolved to enlarge his naval forces and upon his initiative several new units were built. The yards were not only at Gdansk, but also at Puck, where, upon the order of Wladyslaw the IV, besides ships were also built pontoon bridges. The Navy yards were under the direction of de Jansen-Zwan, who for his zeal and his labors, received from the King a silver cup. Gorski relates that these pontoon bridges had 130 anchors and were destined for military operation. One of these bridges was taken to Warsaw.

King Wlayslaw the IV, personally inspected the coast up to the peninsula of Hela and not far from Puck, ordered built two fortresses, one named Wladyslawow and the other Kazimirs. The starostas of the coast received instructions to watch, that the provisioning of the naval fleet be in every way facilitated. In 1637 the King ordered a taxation in the Baltic Sea for the maintenance of the fleet. Guldenstern and Wladyslaw Denhof were made Admirals by King Wladyslaw. The same King gave out, in 1634, rules for the use of the Polish artillery: "Regulations of the brave artillery for the superior and subaltern officers, as also for other military persons, prescribed by His Majesty, by the Grace of God, the Mighty King of Poland, Wladyslaw the IV, in 1634." In it we find the following passage: "You are obliged to promise and to swear before your superior authority, Colonels, First Lieutenants, and Captains, that you will give them due honors and show them dutiful obedience. You are obliged to comply with the orders of the King or of your superiors, be it in quarters or in the fortress, or in which ever place the King and the Crown shall call you. To the enemy you shall oppose the greatest resistance by land as well as by sea."

In 1638, the brother of the King, John, undertook a sea voyage to Spain for the purpose of visiting the Royal family of which he was kin.

He stopped at Marseilles, Toulon, etc., and profiting of the occasion minutely inspected their fortresses. The French suspected him of wanting to gain information about their fortifications. Cardinal Richelieu had Prince John put in prison. The King of Poland took up the cause of his brother and obtained his release but only under the promise never to wage war against the French.

In 1639, the fortification of Puck and Tczew were enlarged and the port of Pilava underwent the necessary repairs. The inhabitants of Gdansk were jealous of the development of the Polish marine, as they thought it constituted a menace to their merchant marine. To undertake a decisive action against the Polish fleet, they allied themselves with the Danes and during several naval engagements captured many of the Polish vessels. The success of the inhabitants of Gdansk was favored by treason in the Polish ranks. On account of the interior complications in Poland, and especially on account of the death of King Wladyslaw, which happened in 1648, all thought of a revenge had perforce to be put off to better times.

After the death of the energetic King Wladyslaw the IV, the naval might of Poland came to an end. The inhabitants of Danzig pillaged the arsenal of Pucks. Just what happened to the ships, nobody seems to know anything about. L. Golcblowski writes us that they disappeared in an unknown manner, that is, not on account of a battle but because of the anarchy in the administration.

The state once so mighty, rapidly declines towards its end. Compelled to cede to its neighbors large territories, spent by frequent wars, having lost about 3,000,000 men by famine and epidemics, having cities and villages destroyed, not being able to revive its commerce, for lack of financial means and of a naval fleet, Poland offers to us a sad picture of destruction and decadence. From now one, the neighbors had nothing to fear from Poland.

The King, John Kazimir, made all possible efforts to revive the naval might of the country, but his projects never took substance. It is true that Poland could utilize the naval fleet of Courland, this country being a vassal state, but this fleet although at the time of Prince Jacob (1643 to 1682) counting forty vessels, half of which were ships-of-the-line armed with 30 to 80 cannons, was always travelling to far distant lands.

During the existence of the Duchy of Warsaw, of the Kingdom of Poland, created by the Congress of Vienna, and of the small republic of Cracow (suppressed in 1846) the Poles not having any coastal territory, could not maintain a national fleet.

In order to complete this historical review, it is necessary to add a few words concerning the efforts to create a Polish fleet during the last insurrection in 1863 and 1864, efforts which, however, completely failed.

Colonel Lapinski had, with authorization of the National Committee, bought in England a ship and manning it with two hundred volunteers entered the Baltic Sea to bring help to the insurgents in Lithuania. His ship was wrecked during a storm in the neighborhood of Memel.

In June, 1863, two other ships were bought and a Frenchman, named Magnan, was commissioned Commandant of the National Fleet. His successor was W. Zbyszewski, formerly a captain in the Russian Navy.

The acquisition of these two ships was mostly to give help to the insurgents upon the coast of the Black Sea and also in the Caucasus.

However, the realization of these projects was frustrated by the measures taken by the Spanish Government which captured the ship Kilinski, and put the entire crew in prison on the 14th of February, 1864.

Thus ends the last chapter of the history of the Polish fleet.

Gas for Raising Steam

STEAM raising by gas has received comparatively little attention in the gasworks of this country, although from the point of view of economy these establishments should be able to operate the system under a decided advantage in that, as the gas is used at the point of production, it would be obtained at a figure which does not have to bear the comparatively high expenditure entailed in distribution. Gasworks, however, are in the position of always having on hand a certain quantity of inferior fuel, such as coke breeze and pan-coke, for which there is no ready sale, and consequently the steam-raising plant affords a convenient means of gettting rid of this. Moreover, while there is always a ready sale for gas, the same cannot always be said of coke, so that by utilizing a certain proportion of this by-product in the boilers the market is to some extent regulated. In this country at the present time, a considerable number of gas-fired boilers are in operation, but experience has chiefly been in connection with coke-oven works (where the surplus gas is often little more than a waste product), with blast furnace gas and Mond gas. So far as efficiency is concerned, the advantage appears to be slightly on the side of the higher-grade gases, but efficiency is a factor which depends more upon the physical condition of the gas used, its pressure, and the structural details of the installation.

COMMON DEFECTS.

Some instructive remarks on the possibilities of various gases for steam raising were made by Mr. J. M. Hunter in a paper he contributed recently to the South Wales Institute of Engineers. Mr. Hunter rightly draws attention to the fact that the defects of the industrial gases as now commonly utilized are their pressure and composition, both of which are liable to fluctuation, while blast furnace gases are almost invariably laden with dust. These variations in pressure and composition render it necessary, even with the most modern installations, to burn the gas with as much as 20 per cent. excess of air in order to avoid the serious loss in thermal efficiency which results from incomplete combustion when the pressure or calorific power increases. A dust-laden gas is particularly objectionable, in that the solid particles adhere to the boiler tubes and flue walls, and very rapidly reduce efficiency. The process of cleaning the gas, moreover, involves a loss of sensible heat, which often amounts to from 10 to 15 per cent. of the total calorific value of the gas, so that the saving effected in the boiler by employing a cleaned gas must be greater than this, and must also compensate for the power employed in operating and maintaining the cleaning plant.

In Mr. Hunter's opinion, with water-tube boilers it is questionable whether cleaning does pay, but with boilers of the Lancashire type, which can be scaled only periodically, cleaning is more or less essential. In most installations the burning gases are permitted to impinge directly on the tubes; thus the rust is burned on in the form of a hard scale. With water-tube boilers, however, it is possible to arrange the gas burners in such a manner that a large proportion of the dust can be fused by the flame and left on the floor. Tests made by the United States Steel Trust have shown that the average efficiency of water-tube boilers fired with an uncleaned blast furnace gas is 55 per cent., and while this could easily be improved to 65 per cent., it is doubtful whether a high efficiency could be maintained for any length of time under ordinary conditions. From the above remarks it can be gathered that the chief drawbacks associated with gas firing are entirely absent when a supply of town's gas is employed, and so far as inequalities in coke-oven gas are concerned it would seem that the greater part of the trouble could be overcome by adopting the duplex system of manufacture whereby the rich and poor gases are separated and used in different streams.

EFFECT OF WATER VAPOR.

Water vapor in the gas, if present in any quantity, has a very serious effect on the efficiency of combustion, lowering the flame temperature and increasing the quantity of heat carried away up the chimney by the waste gases. Losses in this direction may, however, be eliminated by cooling the gas before use to 30 deg. C. or lower. In this respect the system of gas cleaning employed is of importance. This is commonly carried out on either the wet or the dry principle. The wet method possesses the disadvantage that, from the gas-firing point of view, all the sensible heat in the gas is lost, and the gas is generally laden with a fine spray of moisture, which must be evaporated and raised to the flame temperature. In one process the temperature of the gas as it leaves the cleaning plant is about 70 deg. C., and in many cases the moisture in the orignal ore or coal from which the gas is made is quite sufficient to saturate the latter at this temperature. The gas at 70 deg. C., therefore carries only some 2 B.Th.U. of sensible heat per cubic foot, which is almost negligible; and if this gas is burned and the products of combustion pass to the chimney at 250 deg. C., the moisture present is responsible for a loss in efficiency of 5½ per cent. as compared with the result to be obtained by burning the same gas supplied at atmospheric temperature and saturation. This loss rises very rapidly with the temperature of the saturated gas. At 100 deg. C. the gas carries 3 B.Th.U. of sensible heat per cubic foot, whereas the moisture carried at just under that temperature is three times as much as at 70 deg. C. Thus further cooling is necessary, for it does not pay to retain these small amounts of sensible heat when the gas is loaded with moisture.

Another method of cleaning the gas is the Lodge electrical process, in which case the removal of dust takes place at high temperature. In this process the sensible heat carried by the gas is considerable, amounting to 11 B.Th.U. at 300 deg. C., and the temperature of the waste gases leaving the boiler is little, if any greater than the ingoing temperature of the gas. As, however, the gas is heavily saturated at the high temperature (about 250 deg. C.) at which it is used, the flame temperature is considerably reduced owing to the excessive dilution with water vapor of the products of combustion. Mr. Hunter, in criticizing this system, has shown that, whereas the flame temperature obtained will approximate 1,100 deg. C. if the gas is cooled before use, the excess of water vapor carried by the hot gas will be responsible for a drop in flame

(*Continued on page 191*)

Gas Offense Preparation in the United States*

A Record Achievement

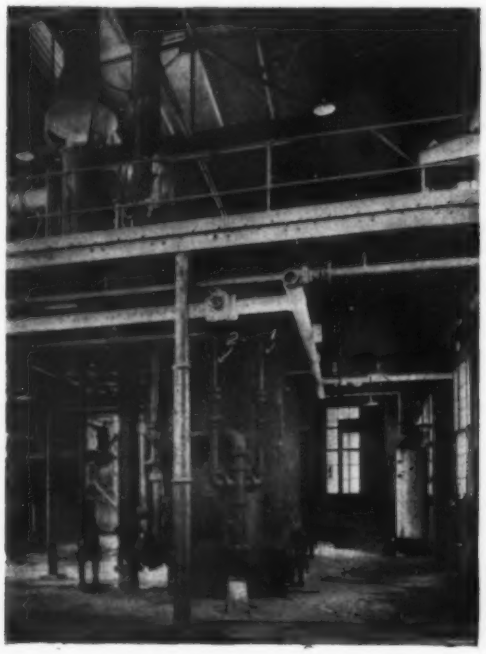
WHEN the United States entered the war, although it was known that poison gas had been used by the enemy and was also used by our Allies, very little information was obtainable in America as to what materials were employed and how they were prepared. The Ordnance Department was at this time charged with the responsibility of procuring all materials for the combatant departments of the Army. The Quartermaster's Department procured clothing, bedding, transportation facilities, etc., which had nothing to do with the actual fighting. In November, 1917, it was decided to establish on Gunpowder Neck, Maryland, which was then a part of the Aberdeen Proving Ground property, a small shell-filling plant. This was designed under the direction of Lt. Col. Edwin M. Chance, who took charge of the construction work at Gunpowder Reservation, breaking ground early in November. The property taken for this purpose was at that time

Phosgene mixer unit, 20 tons a day capacity, combining pure chlorine and carbon monoxide to form phosgene and condensing product

planted in wheat for the spring crops, and no provision for housing men or for transportation of any kind existed. Railroad facilities were extended to the Reservation from the Pennsylvania Railroad, and bunkhouses for a construction force were erected.

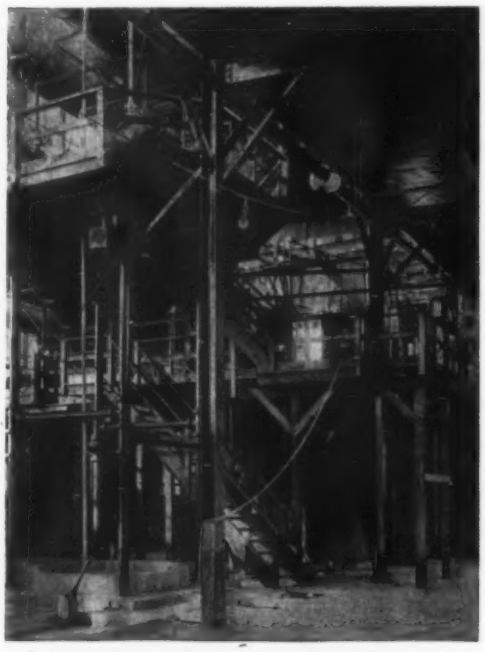
It was then the intention to have the toxic gas itself manufactured by chemical manufacturers throughout the country and shipped to Gunpowder Neck for filling. Owing to the facts, first, that the poison gas materials were new in the sense of not being an established industry; second, that no one would want to manufacture them after the war and therefore the plant would be obsolete; and third, the inherent danger of manufacturing toxic materials, it was soon determined that toxic materials could not be obtained throughout the country, however attractive were the offers, from a financial point of view, which the Government made. Early in December, 1917, therefore it was decided to erect on the shell-filling plant such chemical plants as would be necessary to furnish the toxic materials required for filling the shell. Designs for the chemical plants were ready late in December, 1917, and construction was started, notwithstanding the difficulties incident to a very severe winter. A water supply for manufacturing purposes was obtained by constructing two 36-in. mains from the Bush River. The capacity of the system is 24,000 gal. per min. A dock was erected, and industrial railroads throughout the Reservation were built. Adequate shipping facilities were provided by tapping the Pennsylvania Railroad on the one side, and on the other by water transportation through the Bush River to Chesapeake Bay. In order to obtain the greatest speed in the development of the processes necessary, the aid of such manufacturing concerns as were willing to undertake large-scale investigation was accepted. The two gases which it was then obvious would be required in large quantities were chlorpicrin and phosgene. The manufacture of chlorpicrin was begun on a relatively small scale at the plant of the American Synthetic Color Company, Stamford, Conn., while the manufacture of phosgene was undertaken at the plant of the Oldbury Electrochemical Company, at Niagara Falls, N. Y. The Trench Warfare Section of the Ordnance Department, under Lt. Col. E. J. W. Ragsdale (then Captain), assumed responsibility for these developments. Associated with him were Lt. Col. Wm. McPherson, Major D. J. Demorest, Major Wm. L. Evans, and Major Orland R. Sweeney, all of Ohio State Uni-

*From *The Journal of Industrial and Engineering Chemistry*. An abstract from editorial correspondence.



Carbon monoxide producer unit; (1) oxygen inlet; (2) carbon dioxide inlet

versity. Majors Francis C. Frary and Sterling N. Temple, who were, previous to entering the Army, connected with the Oldbury Electrochemical Company, at

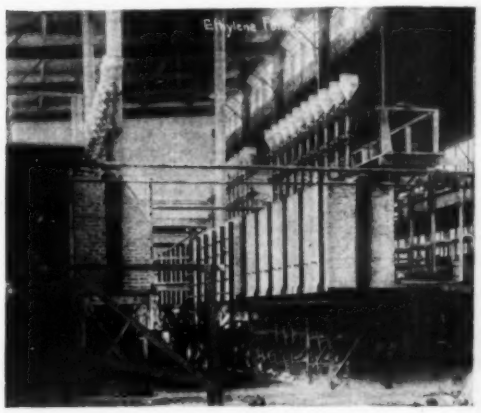


General view of latest mustard gas unit, with a capacity of 12 tons a day

Niagara Falls, had charge of the development of phosgene. Between October, 1917, and the first of February, 1918, gas warfare had assumed much greater importance in Europe. Representatives of the French and British Governments were sent to America and were of the greatest possible help, not only with the information as to methods which they supplied, but also in furnishing an incentive for the work. By this time it was obvious that the Government would be compelled to erect a large chlorine plant in order to supply this important raw material.

Chlorpicrin plant, mixer in lower right hand corner and line of ten stills

In January, 1918, things were not going as satisfactorily as desired, so Colonel Walker, who was at that time Chief of the Chemical Service Section and Assistant Director of Gas Service (the office of Director of Gas Service and the Chemical Service Section are now both absorbed in the organization of the Chemical Warfare Service), was asked to take charge of the Gunpowder Neck project. He was immediately transferred to the Ordnance Department and made Commanding Officer of Gunpowder Reservation (now



Ethylene furnaces

Edgewood Arsenal). The entire project was taken out of the Trench Warfare Section and was made a separate bureau of the Ordnance Department. Colonel Walker received the degree of B. S. from Pennsylvania State College in 1890. In 1892 he obtained his doctorate at the University of Göttingen, and in 1894, he accepted a professorship of industrial chemistry at the Massachusetts Institute of Technology, later becoming director of the Institute's course in chemical engineering.

Under the leadership of Colonel Walker, things began to hum. At this time, the railroad transportation system of the country went to pieces. Nothing daunted, however, military guards were sent out to accompany each carload and shipment of materials, these guards seeing to it that the cars were constantly headed towards Edgewood Arsenal, and in case of breakdown that repairs were quickly made. Later this practice had to be discontinued as it did not meet the approval of the Inland Traffic Service.

In July, 1918, Edgewood Arsenal was withdrawn from the Ordnance Department and made a part of the Chemical Warfare Service.

ORGANIZATION.

Edgewood Arsenal was organized with the following departments:

1—Chlorine plant, complete, for manufacturing caustic soda and liquid chlorine.

2—A chemical plant for the manufacture of toxic materials.

3—A filling plant for filling the shell, Stokes mortar bombs, Livens projector drums, hand grenades, incendiary bombs, etc.

4—Construction, maintenance and stores division.

5—Headquarters military organization.

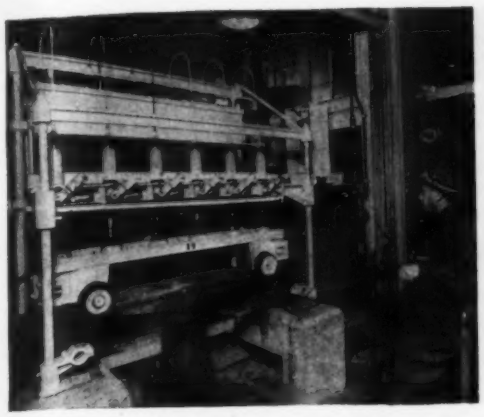
6—Military medical hospital with ample facilities.

7—Executive office. This was moved from Washington to Baltimore, taking the two upper stories of McCoy Hall, one of the old Johns Hopkins University buildings.

While the plant at Edgewood was being completed, and in order to avoid having all the eggs in one basket, such manufacturing firms as were willing to enter into the production of toxic materials were utilized.

The experimental plant for the manufacture of chlorpicrin at Stamford, Conn., was rented, enlarged, and operated by the Government.

A plant for the manufacture of phosgene was built at the works of the Oldbury Electrochemical Company, Niagara Falls, N. Y. Another plant for phosgene was



Machine that fills 75 mm. shells with mustard gas

erected at the plant of Frank Hemingway, Inc., at Bound Brook, N. J.

A plant for bromine was erected at the plant of the Dow Chemical Company, Midland, Michigan.

A plant for chlorine was erected at the Charleston Chlorine Company's plant at Charleston, West Virginia.

Later, there were added the plant of Zinsser and Company, at Hastings-on-Hudson, N. Y.; the National Aniline and Chemical Company at Buffalo, N. Y.; and the Union Dye and Chemical Corporation, Kingsport, Tenn.

CHEMICAL PLANTS.

Plants for phosgene, chlorpicrin, and mustard gas are all in operation, producing an amount of toxic material far in excess of that used in the shell-filling plant. European shipments of toxic gases in bulk began in June, 1918.

PHOSGENE.

Phosgene is a lethal gas of high toxic power. It has a very severe delayed action upon the heart which frequently proves fatal after the immediate effects have apparently disappeared.

The method of manufacturing phosgene as used at Edgewood was worked out in the laboratory of the Oldbury Electrochemical Company under the immediate supervision of Dr. F. A. Lidbury, by Dr. (now Major) Francis C. Frary and Mr. F. A. Stamps. The design of the plant at Edgewood as it now exists is the fruit of the efforts of Majors Frary, Temple, and Demorest. Instructions from Europe were to the effect that the carbon monoxide could be made best by first producing oxygen from liquid air and using pure oxygen in a small water-cooled producer to make pure carbon monoxide. Obviously the great heat of reaction of oxygen and carbon must be carried away by the water rapidly enough to insure life of the converter. By combining the endothermic reaction of carbon dioxide and carbon with this exothermic reaction of oxygen and carbon, a standard U. G. I. gas producer can be employed and carbon monoxide made in very large quantities of high purity. The temperature of the reacting zone can be maintained as desired by regulating the relative amounts of oxygen and carbon dioxide used. The phosgene plant consists, therefore, of a carbon dioxide plant, having a daily capacity of 125,000 cu. ft. of pure carbon dioxide, an oxygen plant with a capacity of 200,000 cu. ft. of oxygen per day, which when used with four producers gives a daily production of 400,000 cu. ft. of carbon monoxide. When carbon monoxide and chlorine are passed over a carbon catalyzer, phosgene is produced with the generation of much heat. It is necessary, therefore, to maintain by cooling a definite temperature. The reaction is practically complete and the phosgene is liquefied by passing through condensing coils immersed in refrigerated brine. At present phosgene is employed in filling the standard caliber gas shell, Stokes mortar bombs, and Livens projector bombs. It is also shipped to the Allies in large quantities in wrought iron drums containing 1,700 lbs. The demonstrated capacity of the plant as it exists at present is 40 tons per 24-hour day. Two additional units are almost complete which will bring the total capacity to 80 tons per day. Phosgene is manufactured also in the Government plant operated by the Oldbury Electrochemical Company, where the carbon monoxide issuing from the phosphorus furnaces is utilized. The capacity of this plant is 10 tons per day and used partly in filling projectiles at the plant, and partly in containers for shipping abroad. The Bound Brook, N. J., plant of Frank Hemingway, Incorporated, has a capacity of 5 tons per day. This product goes almost exclusively to the Allies in bulk.

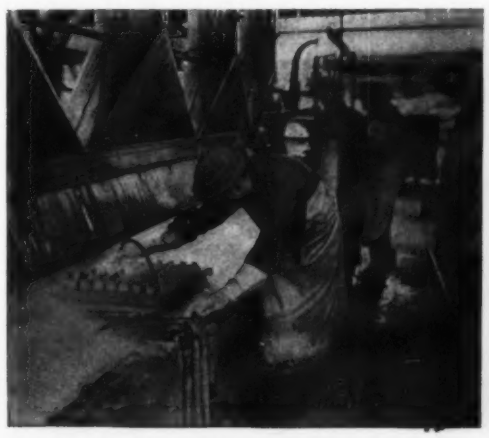
Filling hand grenades, on an endless chain, with stannic chloride

CHLORPICRIN.

Chlorpicrin is a strong lethal gas and is also a strong lachrymator. Being a liquid at normal temperature and pressure, a somewhat higher explosive charge is required in projectiles thus filled than when a real gas such as phosgene is employed. Chlorpicrin is produced by reacting upon calcium picrate with

Filling liquid phosgene into 1700-lb. containers for overseas shipment

bleaching powder in wrought iron digesters furnished with condensers. The reaction proceeds evenly when the temperature is maintained within very definite limits in which the chlorine of the bleaching powder reacts with the calcium picrate. If, however, the proper conditions are not maintained, the bleaching powder reacts with a liberation of oxygen, instead of chlorine,



Filling hand grenades with white phosphorus

and the entire mass foams into the condenser. The chlorpicrin distills from the reaction mass and is separated from the accompanying water by standing for two or three days in settling tanks. At the plant at Stamford, picric acid is produced from phenol and used directly in making chlorpicrin. At the Edgewood plant, the picric acid is provided from other government producing plants. A great portion of the picric acid thus employed has been that rejected by both the U. S. and the Allied Governments on accout of excessive lead

Filling shells with mustard gas

content. Chlorpicrin is employed for filling all types of projectiles either by itself, or mixed with stannic chloride or phosgene.

MUSTARD GAS.

Mustard gas, dichlordiethylsulfide, is an intense vesicant as well as being very toxic when inhaled. It has a marked action upon the eyes, causing temporary blindness, and quickly produces intense hoarseness, followed by inflammation of the lungs. It penetrates clothing readily, producing a flesh wound of much the same character as the burn from phosphorus.

Mustard gas is produced by passing dry, pure ethylene into sulfur chloride at a temperature maintained within very narrow limits. The reaction vessel can be either cast iron or wrought iron lined with lead. The reaction is highly exothermic and a large cooling surface must be maintained. The reaction is a cranky one and is accompanied by destructive side-reactions which are difficult to control. When a batch "goes wild" great volumes of hydrochloric acid are given off, accompanied by highly toxic gases of an unknown composition. As the gas is strongly lachrymatory, such accidents produce great discomfort. Under certain conditions free sulfur is deposited which usually appears as a eutectic with mustard gas, giving a viscous mixture which is mechanically very difficult to handle.

Mustard gas is filled into shell of all calibers and has been sent to the Allies in bulk in large quantities, starting with 1½ tons per day in July, the production has constantly increased, until today the plant has a demonstrated capacity of somewhat over 30 tons per day. Other units to be completed within the month would bring the capacity of this plant to 80 tons per day. In order that other sources of mustard gas could be available in case of accident at Edgewood, or were a greater supply demanded, this Arsenal has constructed a plant with a capacity of 25 tons per day at the plant of Zinsser and Company, Hastings-on-Hudson. A second plant of 50 tons capacity is nearing completion at the works of the National Aniline and Chemical Company, Buffalo, N. Y.

CHLORINE PLANT.

A chlorine plant with a capacity of 100 tons per day and an equivalent amount of caustic soda was designed by the Samuel M. Green Company, of Springfield, Mass., and built under the personal direction of Mr. Green. The electrolytic apparatus employed is that designed by Mr. H. R. Nelson. The cell is known as the "Nelson Cell." Ground was broken for this plant on May 11, 1918, and it was ready to begin operation in August. The entire plant as constructed from first to last without any material change in design and without occasion to tear down and rebuild any part or detail of it—an unusual experience in plant construction.

The chlorine is dried with sulfuric acid and conveyed in a steel-pipe line to the chemical plant where a portion is converted into phosgene, a portion to sulfur chloride, and a portion is liquefied. This liquefying plant has a capacity of 40 tons per 24 hours, compression being effected by a falling column of sulfuric acid. This liquid chlorine goes almost exclusively to the Allies as raw material for further manufacture, although a portion is mixed with phosgene to be filled into cylinders for gas-cloud attacks. The sulfur chloride plant has a capacity of 35 tons per day and furnishes a high grade of material without difficulty.

CHEMICAL LABORATORY.

Major Wm. L. Evans was placed in charge of organizing a laboratory. He assembled a strong organization, and at the outset, in lieu of a laboratory, placed his force in borrowed laboratory space throughout the country, principally at Johns Hopkins University, Bureau of Standards, Washington, and at Ohio State

University. A splendid chemical laboratory, equipped with all modern appliances, has now been provided at Edgewood Arsenal and has been productive of most far-reaching results. Here all of the control processes necessary for the operation of the plants have been worked out, as well as the research incident to factory operation, and results of great value have been obtained. Major Evans has charge also of the Inspection Department, and upon him rests the responsibility of seeing that all shell-filling material is in accordance with specifications, that shell are filled to the proper weight and void, that they are properly painted, marked and tested.

SHELL-FILLING PLANT.

The shell-filling plant is constructed to care for the filling of all caliber of shell from the small 75 mm. to the large 240 mm. Inasmuch as phosgene must be maintained in liquid condition at atmospheric pressure, refrigeration is provided for reducing the temperature both of the phosgene itself and the projectile into which it is to be filled. Conveyors carry the empty shell through rooms held at a temperature of 0° F., discharging the same in front of the filling machines at a temperature far below the boiling point of the toxic gas. The shells are filled to a constant void by an automatic machine in which six shells are handled at one time. They are closed by motors actuated by compressed air and which, in the closing process, are driven until they stall. In this way a uniform closing torque is obtained. Industrial railroads bring the shell from the incoming dump where they are unpacked, inspected, and classified, and carry the filled shell to the outgoing dump where they are weighed, inspected for leaks, painted, marked, and boxed for shipment. Each unit is ventilated with great care, and the tail gas is washed in stoneware towers. In the construction of these towers a standard type of silo was employed. In the combined units there can be filled in one 24-day 80,000 75-mm. shell, 10,000 4.7-in., 50,000 155-mm., and 4.000 8-in. shell. The capacity for filling 6-in., 9.2-in., and 240-mm. shell has not yet been demonstrated. A separate plant is provided for filling smoke shell with phosphorus, and there are also separate plants for filling hand grenades with both gas and smoke-producing material, and for manufacturing incendiary bombs and darts.

CONCLUSION.

Here is a mammoth plant, constructed in record time, efficiently manned, capable of an enormous output of toxic material, and just reaching its full possibilities of death-dealing at the moment when news is hourly expected of the signing of the armistice. What a pity we did not possess this great engine of war from the day American troops first sailed for France, for had we been so prepared how many of our boys who "have gone West" could have returned for the welcome home! Shall we forget this lesson of preparedness? Is this great plant to be scrapped? Possibly wise heads may find a solution of the problem which will add this great resource to American chemical industry, at the same time preserving its value to the Nation as a greater asset, in case of future war, than a standing army.

Dispersoidology and the Theory of von Weimarn*

Some Remarks Upon the Significance of the Crystal and Colloid States

By S. C. Bradford, B.Sc., The Science Museum, South Kensington, London

SINCE Graham laid the first foundation stones of the structure, many significant additions have been made to our knowledge of the chemistry and physics of colloids. The invention of the ultra-microscope by Siedentopf and Zigmondy led to the investigation of Brownian movement by Smolukhovski, Svedberg, and Einstein, and the demonstration of the actual existence of molecules by Perrin. The theory recently elaborated by v. Weimarn is an important extension of the main framework of the science. Although Graham originally distinguished between crystalloid and colloid as distinct classes of substances, it has gradually become evident that these terms should rather be applied to differing states of matter, since, under suitable circumstances, many typically crystalline substances can be obtained in a colloid state. And it further appears that this condition is characterised by the development of a relatively enormous amount of surface, to which the distinctive properties of colloids are traceable.

V. Weimarn's researches completely demonstrate this view, and his theory defines the main conditions which determine the form in which a given substance shall occur. So that, provided the necessary circumstances can be realised, it should be possible to obtain a given substance in either desired condition. The study of colloids therefore develops increasingly into a consideration of specific surface, and the modifications of physical and chemical properties produced by its variation. For even chemical affinity appears as a function of the grain-size of solid and liquid bodies, as may be exemplified by the fact that gold in the finest state of subdivision is soluble in hydrochloric acid. Since all material bodies have at least three kinds of surface, that which separates them from other objects, their atomic surface and that of the electrons of which the atoms are composed, the study of the manifestations of surface energy embraces a universal field, to which v. Weimarn has given the name of "Dispersoidology."

Like most other fundamental precepts of science, v. Weimarn's theory is capable of simple expression. The form in which a substance is deposited from the gaseous or liquid state is conditioned by the number, N, of condensation centres produced, as determined by the equation:

$$N = K\frac{P}{L},$$

where P is the mass of the body about to be deposited, in excess of that which will remain in solution, and L is its solubility, or partial pressure, in the particular state of subdivision concerned. K is a factor which is proportional to the degrees of aggregation of the substances taking part in, or present during, the reaction, and to the viscosity of the reaction medium. Of these, solubility is the quantity which has the greatest influence on the form of the precipitate, and is, in fact, the decisive factor. Thus bodies like soda and copper sulphate, which are easily soluble, occur naturally in large crystals; while, at the other extreme, compounds which are almost insoluble, such as aluminium hydroxide and silicic acid, result in the gelatinous form.

For the production of the colloid condition it is essential that, in the medium chosen, L should be exceedingly small. Then, by varying the value of P, v. Weimarn has shown that five distinct states are produced:

I. Corresponding to solutions which deposit no precipitate for a long time, until after some years the solid phase appears in the form of macrocrystals.

II. Corresponding to solutions which deposit macrocrystals in a short time.

III. In which a precipitate separates in the form of crystalline growth figures (crystalline skeletons and needles).

IV. In which the precipitate appears in the form of plastic masses (so-called amorphous precipitates, curdy and gelatinous masses) which are composed of particles so small as to appear spherical under the microscope and ultra-microscope.

V. The state corresponding to the separation of a precipitate of which the individual grains cannot be differentiated with the aid of our present-day optical instruments. (Homogeneous gels and the first products of their decomposition.)

The influence of concentration upon the form of the precipitate may be explained by the consideration of some examples which, with many others, have been fully worked out by v. Weimarn and his pupils.

The solubility, L, of barium sulphate corresponds to about N/20,000. In order to obtain, at need, a large value of P, the barium sulphate is produced by the double decomposition, $MnSO_4 + Ba(CNS)_2 = BaSO_4 + Mn(CNS)_2$, from the mixing of a litre each of solutions of equal molar strength. By changing the concentration from N/20,000 to N/10,000, no separation of barium sulphate is observed during many months. From N/5,000 to N/1,000, a precipitate falls in a short time in the form of macrocrystals. The progress of the reaction in the neighborhood of the lower limit of concentration is thus described. In the course of the first two weeks an opalescence appeared in the liquid, though no separation of precipitate on the base of the vessel could be observed. After about a month an extraordinary fine deposit of precipitate appeared which might easily have been taken for dust. A month later the mass of the precipitate on the base of the flask was somewhat greater. After six months from the commencement of the experiment the liquid was poured off, the bottom of the flask cut out and examined under the microscope. With a magnification of 500, the particles were seen to consist of practically perfect crystals of apparently 2—2.5 cm. length and a width of from 0.5–1 cm.

With a concentration of N/3,000, the opalescence appeared in from 6-8 hours, and the precipitate had mostly separated within 24 hours. A concentration of about N/2,000 showed an opalescence in from 2-3 hours, and gave a precipitate within 10-12 hours; while changing the concentration from N/1,000 to N/500 reduced the period before the appearance of an opalescence from 3-5 minutes to one second, and the time of separation of the precipitate from within 2-3 hours to ½-1 hour. The precipitate obtained with a concentration of N/1,000 appeared, under a magnification of 15,000, to consist of a few parallel epipedal barium sulphate crystals (of which the largest were about 5 × 3 mm.) and of aggregates of the smallest particles which appeared spherical under the highest magnification. After the expiration of six months, the smaller particles had disappeared, owing to their greater solubility, and the precipitate was seen to consist almost entirely of right-angled crystals, which under a magnification of 500 appeared to be 2-5 mm. long and 1-3 mm. wide.

The third stage commences with a concentration of about N/600. As the strength of the reacting solutions increases, the number of perfect crystals quickly falls, until, at a concentration of N/100, the precipitate consists of compact star-like skeletons and fine needles. At N/10 the star-like growth figures disappear, and the precipitate (from reacting drops) consists entirely of needles of a maximum length of 3 mm. under a magnification of 1,500. When 0.75N/1 is reached the precipitate has become so fine-grained and mutually entangled that its needle form can hardly be discerned under the higher magnification. This is the commencement of the fourth stage. The formation of so-called amorphous precipitates begins in the neighborhood of N/1. The precipitate appears to consist of flocks of different sizes as well as a fine-grained precipitate. Under a magnification of 1,500, the flocks are seen to be composed of spherical grains so small as to appear as points.

The fifth stage begins at about 3N/1 with the appearance of translucent gelatinous flocks. At 4N/1, at a temperature of 100°, a partially transparent coarse-celled gel is formed which quickly falls in flocks. At 5N/1 the gel is formed at 20°, as well as 100°, and is more permanent. When the concentration of 7N/1 is reached the single cells of the gel remain transparent for manf hours. But after about 24 hours the gel falls into a fine flocky white precipitate, which is very plastic. The results are summarised as below:

Concentration of reacting substances.	$\frac{P}{L}$	Form of precipitate.
N/20,000-N/7,000	0-2	I. Macro-crystals appear after many years.
N/7,000-N/600		II. The precipitate appears as complete crystals within a short time.
N/600-0.75N/1	32-14,000	III. The precipitate occurs in the form of growth figures (skeletons and needles).
0.75N/1-3N/1	14,000-60,000	IV. The precipitate appears in different forms—ball-like, curdy, flocky, and gelatinous. These are so-called amorphous precipitates, which appear to consist of spherical grains under the microscope.
3N/1-7N/1	60,000-140,00.	V. The precipitate separates in the gelatinous form, and, during the first part of its existence, cannot be differentiated under the microscope.

By the inoculation of supersaturated solutions, v. Weimarn demonstrated that even the amorphous precipitates are essentially crystalline in nature.

The most permanent sol, or colloid solution, of barium sulphate results at a concentration of N/3,000. But its stability is not great, and most of the precipitate is deposited within 24 hours. Ultra-microscopic examination showed that the number of sub-microns was small compared to those in a typical sol of the same

*P. P. v. Weimarn *Zur Lehre von den Zustanden der Materie.* Leipsig, 1914. 2 Bde.

concentration. Consequently their size increased rapidly, owing to the greater amount of nutrient material, with a corresponding loss of Brownian movement and eventual precipitation. To prepare more permanent sols of barium sulphate, it was evidently necessary to increase the number of crystallisation centres in relation to the nutrient material, and so reduce their rate of growth. This was done by further reducing the solubility by mixing solutions containing 50 per cent. of alcohol. The reaction between $CoSO_4 . 7H_2O$ and $Ba(CNS)_2 . 3H_2O$ was employed, with concentrations varying from N/10 to N/500. The resulting sols were extraordinarily permanent. One containing 0.25 per cent. $BaSO_4$ had not deposited any precipitate after seven years. By mixing solutions containing progressively more alcohol from 1 to 50 per cent, it was shown that the ultra-microscopic particles must consist of the finest crystalline needles of $BaSO_4$. It appears, therefore, that from the first stage to the last the disperse phase is crystalline.

The number of crystallisation centres may also be increased by adding to the reaction medium some neutral substance, which increases its viscosity while taking no part in the chemical change. This progresses more slowly than before, and, by reason of the internal friction, the Brownian movement of the resulting particles is diminished, so that they more readily form centres of crystallisation, while their smaller sphere of movement limits them to a lesser size. A third method for the preparation of sols consists in the employment of reacting solutions of a high degree of aggregation. The greater the degree of aggregation, the less the Brownian movement, and the smaller also the number of particles which will have to combine together to form the slow-moving centres of crystallisation, which will be proportionately increased in number. Thus a sol of the metal barium, prepared by Bredig's method, may be treated with dilute sulphuric acid with the formation of a sol of $BaSO_4$ and escape of hydrogen.

Aluminium hydroxide, as it usually occurs, is a typical representative of the colloid state. This is due to its great insolubility and to the production of associated basic salts as intermediate products during its formation. Small macroscopic crystals of this substance may be obtained by the slow union of extraordinarily dilute reagents, or by artificially increasing the solubility. The former method has long been known to mineralogists. In the case of a difficultly soluble substance like barium sulphate, of which the solubility is about 10^{-5}, we have seen that macro-crystals are produced from the mixing of two litres of very dilute solutions after some years. In the case of a body whose solubility is only about 10^{-10}, the number of crystallisation centres will be so much greater that there will be insufficient nutrient material for them to grow into crystals. So that, to obtain crystals, very large quantities of extraordinarily dilute solutions must be used. When however micro-crystals have been obtained, if they are put into a super-saturated solution obtained in any way they will grow to macroscopic size. This is the basis of the first method. The second method was employed by v. Weimarn, who made use of the greater solubility of aluminium hydroxide at the boiling point. Half a litre of N/2,500 $AlCl_3 . 6H_2O$ was poured into the same volume of N/2,500 NH_4OH solution, and the mixture boiled until an opalescence was clearly visible. The heating was then discontinued and the solution cooled to room temperature. In 10-12 days a fine-grained precipitate of $Al_2O_3 . 3H_2O$ had been deposited, which, under a 15,000 magnification, was observed to consist of spear-shaped needles 3—4 mm. long.

The stage of so-called amorphous precipitates begins with aluminium hydroxide at about N/500. At N/1 coarse-celled gels are formed. And at 3N/1 the mixture sets to a solid gel.

By application of similar principles a typical crystalloid, such as common salt, can be obtained in the colloid form. For this purpose it is merely necessary to choose a medium in which the solubility is sufficiently small. By pouring 4 c.c. of a saturated solution of NaCl in methyl alcohol into a mixture of 30 c.c. propyl alcohol and 10 c.c. ether, a precipitate in the form of growth figures is obtained. If a mixture of equal parts of propyl alcohol and ether is employed, the precipitate appears amorphous under a 300-times magnification. With 30 c.c. ether and 10 c.c. propyl alcohol a voluminous precipitate of fine-grained amorphous structure is obtained. Finally, by pouring 4 c.c. of the saturated methyl alcohol solution into 40 c.c. ether, a strongly opalescent sol is obtained, with a characteristic reddish-brown color by transmitted light, and which deposits only minimal precipitate in 4 hours, remaining otherwise unchanged.

These researches explain the natural occurrence of large crystals of insoluble bodies either by deposition after many years from enormous volumes of very dilute solutions, by the gradual diffusion of the reacting solutions into gels, or by the slow crystallisation of the latter.

The Study of the Sediments as an Aid to the Earth Historian*

By Eliot Blackwelder, Department of Geology, University of Illinois

Objectives of the Earth Historian.—We are, of course, still immensely far from our ultimate goal, which is a complete understanding of all the past states and events of the earth, or as Professor Salisbury used to put it, "the complete geographies of all past epochs." Progress toward this unreachable goal will be most favored if the advance is made rather uniformly, all along the front. It is true that such progress is often made by pushing out salients, but the further extension of such salients is usually impossible without corresponding support from the flanks.

In the past we have gone ahead much farther along certain lines in geologic history than along others. The history of life and of faunal succession has been cultivated assiduously for generations and is, on the whole, much better understood than other phases of the subject. Although not so well known in detail, the history of diastrophism is now fairly well blocked out and the mere continuation of studies already under way is likely to afford us in the near future a serviceable understanding of the sequence of major earth movements.

The most backward points in the general advance just now are in two sectors: That of the history of climate, and that of the principles of chronology and correlation.

The importance of climate arises from the fact that it is one of the most powerful factors, if not indeed the dominant factor, controlling not only the sculpture of the land but the nature of the deposits that are made both on land and in the sea.

Secondly, the principles of correlation must be understood better than they are now, before we can bring into their proper time relations the various events and conditions of which the sediments give us record. In spite of the impressions in elementary text books of geology, I think it will be generally admitted, by those who have carefully considered the question, that we do not yet know these principles with satisfactory accuracy. If we did, we should not have such anomalies as the actual interbedding of strata in Montana containing marine invertebrates assigned to the Cretaceous with those containing land plants identified as Eocene; or as the Triassic in Idaho resting conformably on rocks containing only Pennsylvanian fossils. Many other cases of similar perplexity will occur to those who have had much to do with age questions in stratigraphy. All things considered, it seems to me that the improvement of correlation methods and a more general acceptance of these improvements is at the present time the thing most to be desired by the earth historian, for nowadays it is one of the chief causes of friction among us.

What service can the study of the sediments and sedimentary rocks render in connection with these two problems? First it offers the best and most comprehensive means of working out the history of climate. We already understand rather fully the climatic significance of such deposits as beds of coral limestone, of tillite, and of saline formations. We have probably reached a similar comprehension of the red beds, loess, and certain other types, although we are not yet fully agreed among ourselves regarding them. Before long we may expect to know as fully the climatic significance of the coal-bearing gray sediments, and eventually even of most of the marine deposits. For even among the latter no matter how great the importance of the work of bacteria, algae, foraminifera, and other organisms is, it becomes increasingly evident that the very activities and processes of these organisms are largely dominated by climate, either directly or indirectly, and that they are forced to make a record of climatic changes in the marine sediments to which they contribute. For example, the prevalence of siliceous in place of calcareous ooze in the Antarctic Ocean is probably due to biochemical factors that depend on climate.

The study of climatic history is not only necessary for its own sake as a division of the larger earth history, but it has an important bearing upon the attainment of the other desideratum, namely, more reliable correlations. Climatic changes are widespread in their influence. Some, like the cooling off during the last glacial period, seem to have affected the whole earth. They influence both land and sea deposits, and hence leave their impress on all sedimentary formations. In comparison with the slow progress of geologic events, the effects of climatic change are felt quickly. We seem justified in believing that altered climates do not ordinarily migrate slowly from region to region, and on this assumption it may generally be presumed that the results are essentially simultaneous over large areas. For these reasons climatic changes should serve as very delicate indicators of time relations. They are likely to be especially valuable because their record is most clear in the terrestrial sediments, where fossils —our customary reliance— are apt to be rare or absent.

From the earliest days of geology attempts have been made to correlate strata in different places by means of lithologic character. Many of these attempts have met with either failure or only partial success. In comparatively recent years, however, more refined methods have yielded much better results. For example, Rogers and Stone in their recent study of the Lebo shale of Montana have shown that it can be identified over large areas by its andesitic particles, which record eruptions of volcanoes farther west at a single epoch in Cretaceous times.

In the future it will undoubtedly be possible to make far greater use of the physical characteristics of sedimentary rocks in correlation—not so much by a direct matching of similar rocks as by an indirect process of first elaborating from the rocks the climatic and physiographic conditions and their changes in time, and then correlating these. It should in fact be as feasible to correlate by means of climatic history as to correlate by diastrophic history. Indeed it is already beginning to be the practice of the most progressive stratigraphers to make their correlations not simply on the basis of faunas nor on the basis of diastrophism, but on the compound basis of life, climate, topography, vulcanism, and diastrophism with due regard to their mutual relations and dependences and their relative values. It is my own expectation that this practice will soon become general.

What Is Needed.—We may reasonably hope to understand eventually all of the sedimentary rocks at least as well as we now know any; but at present our knowledge is very uneven, being tolerably complete for some types and very slender for others. Among the sediments which are as yet but partly understood the following may be mentioned by way of illustration of our needs: limestone conglomerates and oolites, sedimentary iron ores, chert, jasper, etc., gray flags and shales with lean faunas, dolomites, phosphorites, greensands, black oily shales, lithographic limestones, and rhythmically alternating shale and limestone. Of course, there are many others.

To advance more rapidly this part of the scientific battle front, several things are needed. Among the most useful are the prolonged and intensive studies of certain modern types of deposits and the processes of their deposition, as illustrated by the investigations that have been carried on recently by T. W. Vaughan and his associates in the Florida region, as well as by the careful study of mountain stream work by G. K. Gilbert in California. Some of these problems are too large to be attacked by most individuals, but require for their successful execution the aid of our strongest scientific institutions and the co-operation of a number of investigators over a period of years.

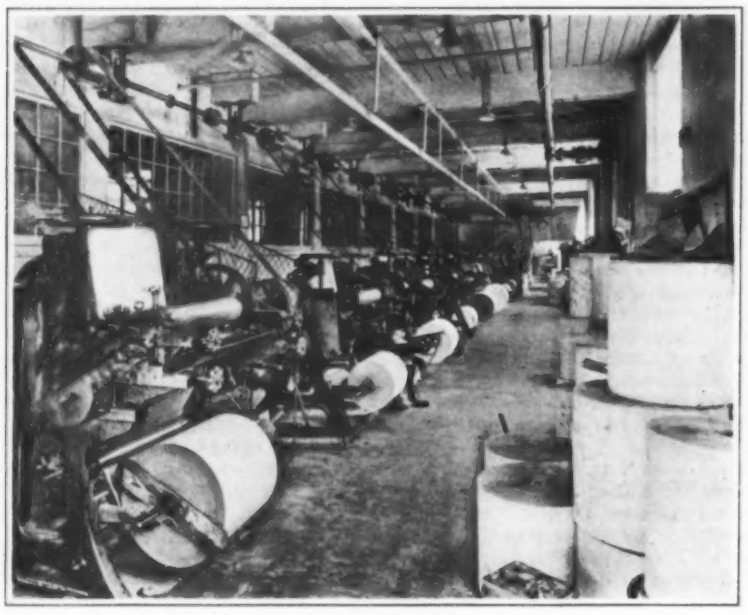
Hardly less valuable are the close and detailed studies of ancient sedimentary rocks, such as Barrell's interpretation of the Mauch Chunk shale, the study of the western Red Beds by C. W. Tomlinson, and of the dolomites by half a dozen or more geologists in the last few years. Probably this method must be our sole reliance in the case of certain peculiar sediments which, so far as known, are not being formed on the earth at the present time. These are illustrated by the thick, rich beds of phosphorite in Idaho and perhaps by the stratified iron ores of eastern Brazil.

Our understanding can be advanced in a most helpful way also by careful experimentation, such as that on sun-cracks reported by E. M. Kindle, or the bacteriological experiments of Drew and others on the precipitation of calcium carbonate from sea-water and the formation of oolites. On the whole there has been much too little of this sort of work in the last few decades, perhaps because sedimentary studies have been left largely to the stratigrapher who is rarely, by force of habit, a laboratory experimenter. We shall need in this work the co-operative aid of expert chemists, bacteriologists and others not ordinarily interested in geologic matters. The whole subject of diagenesis, or simultaneous alteration of sediments, is doubtless in the province of the bio-chemists and colloid chemists, if only we could induce them to assume the task.

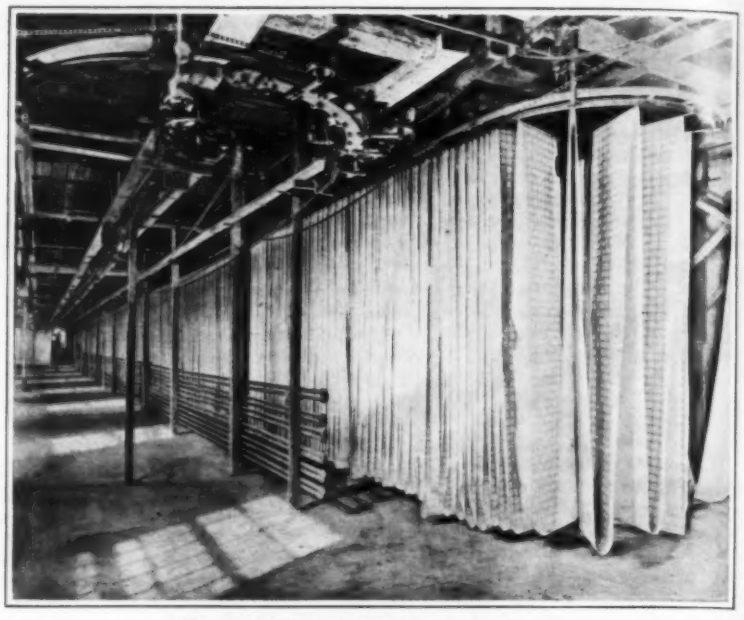
It might seem, at first thought, superfluous for me to

(*Continued on page 192*)

*Proceedings of the National Academy of Sciences.



Machines used in embossing wall paper



The finished paper hung on racks to dry

The Manufacture of Wall-Paper

Interesting Process Carried Out in the Production of This Well-Known Household Commodity

WOMEN today are taking a keen and intelligent interest in everything that concerns their homes, and they do not hesitate to apply themselves to the understanding of subjects that their mothers and grandmothers were content to believe could only be comprehended by "men folks." They have acquired a working knowledge of the relative value of foods, the chemistry of cookery, practical hygiene, and of art as it applies to home decoration. However, very few people, either men or women, know how the paper that decorates their walls is made. The process is usually looked upon as a sort of trade secret, though it need not be so. Very little has been published about wall-paper making, because the men who know how it is done are the kind who do things instead of talking about them. The average intelligent person probably knows less about the manufacture of wall-paper than about any other manufactured article that is in general use, though it is an intensely interesting process.

It is really fascinating to see the paper come down in an endless strip and pass around the big drum that is the main part of a wall-paper printing machine.

Arranged at intervals around the drum and pressing against the paper are rollers, each one of which carries in relief a portion of the pattern. As the paper passes around this revolving drum, each of these rollers prints upon it one of the colors that go to make up the complete design. The color is carried up to these rollers from the pans that contain the supply of color by swift running cloth belts. When the paper comes out at the other side of the machine it shows the complete design. It is taken from the machine on a broad canvas belt, at the end of which it is picked up by an ingenious device that places a stick or wand crossways under the paper and swiftly carries it on sprocket chains up to the ceiling. The paper hangs in loops from these sticks, reaching from the ceiling almost to the floor, and slowly disappears down the long drying room, the heated atmosphere of which quickly removes the moisture.

As the paper comes from the drying room it is automatically wound into big rolls known as reels. These reels are then put onto a rolling machine in charge of a woman operator. The paper comes toward her, along a wooden trough, and is mechanically wound on a rapidly revolving steel rod. When the operator sees a mark in the margin she stops the rolling machine and cuts the paper off, for she knows that she has what is known as a double roll. These rolls are then made up in bundles of fifty, each bundle being wrapped in stout paper ready for shipment to the wall-paper dealer.

But this is not by any means all there is to the manufacture of modern wall-paper. The work that has to be done before the printing machine is brought into use and the processes through which many of the papers pass after they are printed involve the most difficult and time-consuming labor.

Before the pattern is printed the paper in most instances must be given a plain foundation tint, known as a ground color. This is done by a machine that applies the color and spreads it evenly by means of a number of brushes that scrub crosswise of the paper and are worked by mechanical arms. From this machine it passes into the long drying room, and when it comes out is in the form of a large roll ready for insertion into the printing machine.

Even earlier than this, for months, in fact, before the printing of the paper is begun, the work of making the printing rollers has been carried on slowly by skilled workmen, who cut and fit small strips of brass, which they drive into the face of the wooden roller to conform to the design marked on the surface of the roller. Some parts of the thin brass, and the cells thus formed are filled in with felt. Some papers are printed from copper rollers upon which the pattern has been carefully and patiently engraved by hand.

Before the making of the rollers can be begun the parts of the design that are to be printed in each color must be separately drawn and transferred to the rollers.

The work of the designer, naturally, precedes all other work, for his water color drawing of the pattern showing the paper just as it will appear when completed is the starting point.

After the paper is printed, it often is embossed before being rolled ready for the market. This is done on a special machine in which the paper passes under a steel roller the entire surface of which has been engraved to represent the threads of a woven fabric, the roughness of brush stippling, the grain of leather or some other texture. As the paper passes between this roller and a larger one which has a comparatively soft surface the texture effect is pressed into the wall-paper.

Many wall-papers in which part of the design appears in gold or other metallic bronze are printed with liquid gold color applied by one of the printing rollers just as the other colors are. In the manufacture of the paper known as "varnish golds" a printing roller applies the varnish to these portions of the design. The paper then passes through a machine which dusts the metallic powder upon it, the powder adhering to the portions where the wet varnish is and the surplus being drawn off by a suction or air.

Some borders that have a prominent outline of gold or other metallic bronze have had the outline hand-printed in an adhesive material from a carved wooden block, the metallic powder being applied by a second workman and the paper hung from the ceiling to dry.

The cut-out borders are frequently cut out by a machine in which the paper passes under a revolving roller that has upon its face a sharp metal strip made to conform exactly to the outline of the edge of the design of the border.

The basis of the colors used in printing most wall-papers is a fine white clay which is tinted with aniline or other harmless colors. This material is mixed with an adhesive substance to about the consistency of thin cream in large mechanical agitators. An incident that should be reassuring to people who fear that the colors used in wall-paper may be harmful occurred during a recent visit by the writer to one of the large wall-paper factories. In the color-mixing room was a large cask of green coloring matter, from which the wall-paper man picked up a piece to show to the writer. It was moist color and adhered to his fingers. He promptly placed his fingers in his mouth to soften the color in order that he might be able to wipe it off more easily.

Some papers, such as tile designs and other patterns for bathrooms and kitchens, are given a complete coat of varnish after they are printed to make them so that they can easily be wiped clean.

Putting up the paper into commercial rolls

The Way of a Ship at Sea*

Stream Line Motions and Waves

THE theory of stream line motions and waves is one of the least known among those relating to the way of a ship at sea. In order to understand completely the behavior of a floating, moving body, it is necessary also to have a complete knowledge of the laws governing the motions of the element supporting that body. It is undoubtedly on account of the complexity

*From *Shipping World*.

of these motions and their theory, embodying as it does advanced mathematics, that this subject is less understood than it deserves to be.

(*a*) STREAM LINES.

In considering the phenomenon of water in motion, one of the most elementary forms of this motion is that of water flowing in one plane. Consider the case of a rectangular channel of constant section through which water is flowing. Each particle of water is moving along a straight line. Now, put into this channel a body of constant section, say a circular cylinder, with its axis perpendicular to the surface of the water and extending to the bottom of the channel. Each particle of water will now be deflected by the cylinder and will have a definite path past it, this path no longer being a straight line except for particles a long way from the cylinder. The path taken by the particle is called a stream line. The general definition of a stream line is, that it is the line, whether straight or curved, that is traced by a particle in a current of liquid.

The accompanying diagram, Fig. 1, shows the stream lines past a cylinder ACB. The liquid is supposed to be flowing along straight lines parallel to AB and the cylinder then placed in it with axis vertical. It will be noticed that the stream lines near to the axis are much more curved than those farther away, but that the latter begin to get curved some distance before they reach the cylinder. Also, that in the regions near A and B they are widely spaced, while at C they are close together. Now imagine the spaces between the lines to be tubes with water flowing through them. Where the tube is wide the velocity of the water is small, and where the tube is narrow the velocity is great. So that the velocity past C is a maximum, while at A and B it is a minimum.

It is an elementary law of fluids flowing through pipes that where the velocity of flow in the pipe is a minimum the pressure on the walls of the pipe is a maximum, and *vice versa*. Thus the pressures near A and B are greater than at C. Now, in a pipe the material of the pipe can withstand the pressure without distortion. In the case of a liquid flow, however, the hypothetical boundaries of the tubes cannot withstand any of these bursting pressures, and this difference of pressure makes itself evident by the formation of a wave. Where the pressures are greatest the water is heaped up and we get a crest of a wave at A and B. Where the pressure is a minimum, at C, we get a trough. If now we imagine the water to be still and the cylinder moving through it we get the same effect. This applies generally to all bodies moving through a liquid, and is the fundamental reason why we generally get a crest of a wave at the bow and stern of a moving ship and a hollow amidships.

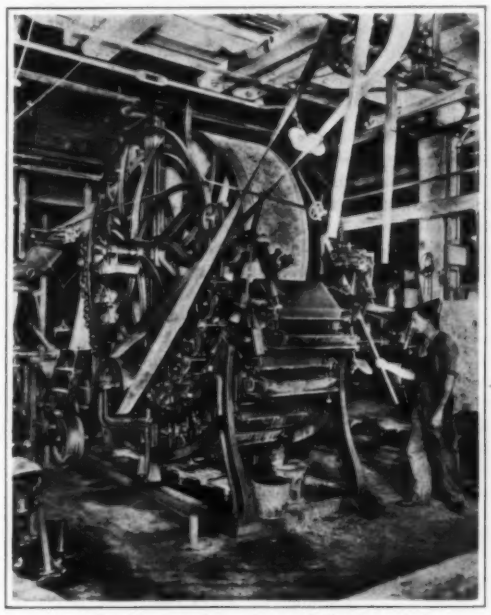
With such a bluff object as a cylinder, if it were placed in water flowing with any great velocity, in the regions of A and B the motion would be very confused and would consist of swirls or eddies. If the water were flowing in the direction of A to B this eddy motion would be more pronounced at B than at A. In the same way, if a body be moving through water there is a great tendency to form eddy motions at its after end. These eddies absorb energy for no useful purpose. For this reason the after end of a submerged buoy is generally made very fine. Thus the section of a propeller bracket is usually egg-shaped, with the blunt end forward.

(*b*) WAVES.

There are in general two principal systems of wave motions. These are spoken of as (1) Waves of translation, and (2) Waves of oscillation. Waves of translation are only to be found in shallow water and consist, generally, of single waves. Fig. 2 shows the general appearance of such a wave. The peculiarity of this type of wave, as distinct from the wave of oscillation, is that the whole bulk of the water forming the wave moves forward with a velocity depending upon the depth of the water. The speed in knots is given approximately by the formula $3.4\sqrt{d}$ where d is the depth of water in feet.

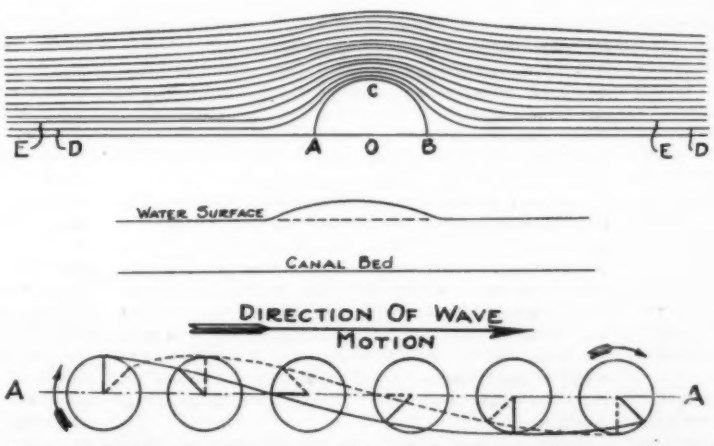
This property was made use of in a practical way by the so-called "fly" boats that were used for fast passenger and goods traffic on our canals. These were light boats which were started by causing the towing horses to gallop. At first the resistance increased as the speed increased, until at last the speed of the waves of translation for the depth of channel was reached, when the boat simply floated on the wave and was borne along upon it with very little resistance, the horses merely trotting along in order to keep up the motion. This also explains why it is that fast-running boats, such as torpedo-boat destroyers, in shallow water often attain speeds far in excess of their designed speeds and with less power.

The wave of oscillation is the one with which we are most familiar. As its name suggests, the water forming this wave does not move bodily, but oscillates about a fixed position. It is usually accepted that, in deep water, each particle moves in a vertical circular orbit. Fig. 3 shows a series of particles in the surface



A modern wall paper printing press

of such a wave. Each is moving in a clockwise direction round its own centre, the centers being on a level line AA. The full radial lines show the relative position of the particles at one instant, and the curved line passing through these points show the wave surface at this instant. The dotted radii show the positions when they have rotated through a further 45 degrees, and the dotted wave line through these points shows the position of the wave surface at that instant. It is seen that this revolution of the particles causes the formation of a wave, that the lines of crests and hollows are advancing from left to right, but that each particle of water has, on the whole, no forward velocity. Actually, in the crest it is moving forward with the velocity of the wave system, and in the trough it is moving backward with an equal velocity. This velocity is independent of the depth of water, but depends upon the length of the wave. This is the basis of the Trochoidal Wave theory which is the generally accepted one for waves in deep water. It will be noticed that the crest of the wave is steeper than the trough.



Above, the liquid stream lines past a cylinder; center, general nature of translation wave in shallow water; below, the deep water wave of oscillation

As we go below the surface the orbits become smaller in radii until at a great depth there is practically no motion. In shallow water the orbits are ellipses with major axes horizontal. This causes the waves to be much steeper and shorter, and at the same time the velocity is reduced.

Anyone who has watched a series of waves breaking upon a beach will have noticed that often the waves far out at sea are moving along with lines of crests set obliquely inclined to the run of the beach, whereas at the beach they run in and break parallel to it. What happens in this case is that the end of the line nearest to the beach reaches shallow water first and its speed is thereupon reduced, thus the lines of crests bend round with the ends nearest the beach becoming more and more parallel to it. At the same time the wave gets steeper and shorter. Finally the shallow-water oscillating wave breaks down as the water becomes very shallow and in its place a wave of translation is formed. This rushes up the beach and carries with it floating objects and shingle.

If we study the formation of waves at sea we find that at first there is the creation of a uniform pattern of minute waves all over the surface, then the growth of the waves to leeward, so that after a time there is a certain size of wave corresponding to the distance from the windward shore. The growth of the larger waves at any place is accompanied by the partial obliteration of the shorter waves which were there before. Finally, there is a definite length of wave at any spot which is the dominant wave for that locality for the actual force of the wind, and any shorter wave that may exist appears as a mere ripple upon its surface, while a longer wave is only to be detected by the presence of a sort of heaving motion which runs through the whole system. Thus in a storm at sea there will most likely be a combination of waves of about 300 to 600 feet long, 30 to 40 feet high, with a swell of about 1,150 to 2,500 feet long and 20 to 30 feet high.

Scattering of Light by Dust-free Air

IT is now well established that the luminosity and blue color of the sky on very clear days and at considerable altitudes above the sea-level can almost completely be accounted for by the scattering of light by the molecules of the air, without postulating suspended particles of foreign matter, such as were thought necessary by the earlier writers. The present paper gives an account of a laboratory experiment exhibiting the scattering of light by dust-free air. The source of light (either a carbon arc or a quartz mercury lamp) was arranged to give a convergent beam, a quartz lens being used. This beam passed through a quartz water-cell to absorb heat rays, and then into the experimental vessel. The latter was in the form of a cross ABCD, made of brass tubing 1½ in. in diam., and its interior was dead-black. The light entered by the quartz window in A and passed through a rectangular diaphragm to the end of C, where it was stopped by the end of the tube. The beam was observed through a glass window at the end of D. The opposite tube B constituted a black cave, giving the necessary black background against which the feeble transverse luminosity of the beam could be observed. In spite of all precautions, enough light was diffused by the walls of the tube to enclose this black background in a luminous ring, which, however, was not bright enough to cause inconvenience. With ordinary air in the apparatus a very bright track due to scattering by the dust particles was observed, but with well-filtered air only a blue track along the beam was visible, much fainter than the original dusty track, but visible without difficulty when the eyes had been rested in the dark. The track of the beam in dust-free air was much bluer than the original dusty track, which was about the same color as the arc, and also was much bluer than the ring of light scattered by the walls of the vessel. When the vessel was exhausted the blue track disappeared, nothing remaining except the ring of light diffused by the vessel. Various tests and precautions seem to prove beyond doubt that the observed scattering was not due to dust, but that it is a property of pure air. Spectroscopic investigation showed that what had been observed could not be attributed to fluorescence, a 2-hour exposure bringing out faintly the great cyanogen band at λ 3,880, which is photographically the most conspicuous feature of the carbon arc spectrum. Polarisation tests showed further that the scattered light is almost completely polarised. Visual examination with a nicol showed that the beam was invisible when the prism was held with its short diagonal horizontal. Thus the vibrations are transverse to the direction of propagation, as in all cases of scattering by particles small compared with the wave-length. Similar results can be obtained with other gases. Hydrogen gives much less scattering than air, oxygen about the same, CO_2 decidedly more, but the scattered light in all cases is the blue of the sky.—*Note in Sci. Abstr. on a paper by R. J. Strutt.*

A Novel Observation Upon Mosquitoes

Some Notes Regarding Their Flight Through Horizontal Water Pipes

By W. W. King, Surgeon, United States Public Health Service

An attempt to get rid of or to materially reduce the excessive number of mosquitoes at my own residence in St. Thomas, Virgin Islands, resulted in some very interesting experiences and brought to my attention certain points in the habits of mosquitoes which apparently have a practical application in antimosquito work, but to which I cannot find reference in the literature at my command.

In various works treating of mosquitoes and measures for their extermination I found reference to the necessity of screening the downspouts leading into cisterns, but no distinction was made between the spouts which descend perpendicularly and those running more or less horizontally for some distance. The following observations, so far as they go, indicate that mosquitoes do make a distinction, because they readily utilized perpendicular spouts to pass in and out, but did not enter through spouts that had a considerable horizontal section. On the other hand, horizontal pipes nearly 200 feet in length were no hindrance to their escape when they were breeding in cisterns. The conditions under which these observations were made are given in considerable detail for the better comprehension of circumstances which might have affected the behavior of the mosquitoes.

The house crowns the summit of a rather steep hill, 240 feet high, at the edge of town where the houses are sparsely scattered. Hence it seemed reasonable to suppose that the elimination of breeding places on the premises would reduce the number of moquitoes to a minimum. As is usual in St. Thomas, the water supply is rain water collected from the roof into cisterns and tanks, in this case two underground concrete cisterns, "A" and "B," and a small iron tank "C." From the cisterns a windmill pumps the water to a cedar tank, "D," in an ancient stone tower, whence it is piped throughout the house.

Search for mosquito breeding places showed larvæ in good numbers in both cisterns and in the iron tank, but not in the tank "D" in the tower, and it is worthy of note here that even when mosquitoes were most abundant in the house, larvæ were never found in this tank, although there were unscreened openings in its board covering, and the dimly lighted and wind-protected interior of the tower and the always-open door below would seem to afford a favorable avenue to the water above. The rim of the tank is 29 feet above ground, a height apparently not prohibitive for mosquito breeding, because I have found larvæ in tanks on the roofs of houses in St. Thomas at much greater heights.

The cistern "A" under the front veranda had a close-fitting trapdoor always closed, and the overflow outlet was well screened, so that the only means by which mosquitoes could enter or leave this cistern was by the unscreened in-flow pipes from the roof. A 2½-inch down-spout "E" descends perpendicularly except for the lower 2 feet, where it bends at an angle of 22.5 degrees, then makes a right-angle turn into the cistern. The entire length of this spout is 14 feet. The downspouts "F" and "G," 4 inches in diameter, discharge into the cistern through a horizontal pipe "H," 4 inches in diameter from "F" to "G," and 5 inches from "G" to the cistern, a distance of 32 feet.

Mosquito larvæ disappeared shortly after the downspout "E" was screened. "F" and "G" were left unscreened, but larvæ never reappeared in this cistern, although mosquitoes were abundant in the house and on the veranda for several months later.

The slight deviation in the course of the upright spout "E" was no obstacle to the passage of mosquitoes, yet they did not enter by the way open through "G" and "H" (12 feet down and 32 feet horizontally), either on account of the distance or the horizontal direction, or both factors combined, although the size of the pipe was larger than "E." As shown by the flicker of candle flame, there was a slight upward current of air through the horizontal pipe, but it was less than that through the perpendicular spout, against which mosquitoes did enter the cistern; hence the air current could hardly have been a factor. If anything, these air currents, by carrying the scent of the water upward, would have favored the use of the pipe "H" by mosquitoes.

The cistern "B" has two mosquito-proof trapdoors, but one of them has remained open more or less constantly. A 6-inch overflow pipe "I," 25 feet long, runs horizontally just beneath the surface of the ground to discharge over a terrace wall. Water enters the cistern by a 4-inch downspout "J," 10 feet high, through a 4-inch horizontal pipe "K," 12 feet long; and by the downspouts "L" and "M," through the horizontal pipe "N." The spout "L" runs downward about 12 feet, and the horizontal section "N," from "L" to the cistern is 20 feet in length; both are 5 inches in diameter.

None of these pipes were screened yet the mosquito larvæ disappeared from the cistern after the trapdoor was kept constantly closed, and reappeared only once later, in small numbers, probably from mosquito eggs deposited on the water in a sagging gutter, and washed into the cistern. No more larvæ were noticed after repairs were made to the gutter.

It is believed that the mosquitoes which hatched in this cistern after the trapdoor was permanently closed, and those hatched from larvæ remaining in cistern "A" when the spout "E" was screened, found their way out through the unscreened spouts in spite of their horizontal sections, aided possibly by the upward air current. A comparatively strong current of air entered cistern "B" through the overflow pipe and passed out with less force, through the rain spouts, but none of the air currents were sufficiently strong to hinder the flight of mosquitoes. A considerable portion of the surface of the water in these cisterns could be observed for dead mosquitoes, but only an occasional one was seen, too few to account for the number of larvæ which had been present.

To test this point, a jar containing some hundreds of pupæ and well developed larvæ was suspended in cistern "B," and the spouts were screened to catch the mosquitoes at the point of escape. When observed some days later it was found that the screens had been imperfectly fastened and had become disarranged by heavy rains, so that mosquitoes could easily pass. The mosquitoes had hatched and disappeared, but as none were caught the experiment was inconclusive, and it can only be supposed that the mosquitoes escaped by the rain pipes as the only way out.

The iron tank "C" has a small overflow opening on one side and a number of small holes in the top. One 3-inch downspout "O" descends perpendicularly from the roof, a distance of 10½ feet. All openings were screened or plugged except this spout, yet mosquito larvæ persisted until the spout also was screened.

The plague of mosquitoes was only slightly if at all diminished by the elimination of the cisterns and tank as sources of supply. Search for other breeding places was unsuccessful for a long time until the septic tank "P" was opened. Mosquitoes by the hundreds flew out of the opened trap, and the foul water at the bottom was teeming with larvæ. This tank had not been considered a possible breeding place as it was thought to be inaccessible to mosquitoes because the trapdoor was always tightly closed and the ventilator was effectively screened. The only other openings are the 4-inch drain "Q" and the 5-inch drain "R" carrying water-closet, bath and kitchen waste from the house. At the highest points in each drain are ventilating pipes, "S" and "T," 2½ and 4 inches in diameter.

Inasmuch as mosquitoes did not seek the water in the cisterns through horizontal rain pipes comparatively short in relation to the drains it is not presumable that the female mosquitoes would enter these ventilators and traverse the long horizontal pipes to reach the water in the septic tank. Yet this water was alive with larvæ, a fact apparently explainable in only one way; that the mosquito deposited her eggs on the water in the bowls of the toilets, and they were flushed through the drains into the septic tank where the larvæ developed.

The mosquitoes bred in this place had but one way to escape, which was to fly back up the drains and out the ventilating pipes. The horizontal distance to the bottom of the nearer outlet, "S," is 82 feet, and to the farther one, "T," 191 feet. The upright ventilators are 13 and 14 feet high, respectively. Positive evidence that the mosquitoes did escape by this route was secured by covering the ventilator hoods with cloth netting and catching a large number of mosquitoes inside the netting. In their passage upward through the drains, the mosquitoes were probably aided somewhat by an upward current of air. The odor of kerosene thrown on the water in the tank was perceptible at the nearer ventilator in about five minutes.

In a few days after screening the ventilators and oiling the septic tank, the plague of mosquitoes sensibly diminished, and in a short time the house was practically free from them. These mosquitoes were roughly identified as *Culex quinquefasciatus*. At first there had been some white-striped mosquitoes apparently aëdes, but they were not seen after the cisterns and iron tank were free from larvæ.

The chief points of these observations are as follows: (*a*) Mosquitoes entered and left cisterns through unscreened perpendicular waterspouts 2½ and 3 inches in diameter and 14 and 10 feet high.

(*b*) Mosquitoes did not enter cisterns through larger unscreened water spouts when these pipes had a horizontal section from 12 to 32 feet long. No observations were obtained of a horizontal distance of less than 12 feet.

(*c*) Mosquitoes bred in the cisterns and septic tank and having no other means of exit passed through horizontal pipes 4 and 5 inches in diameter for a distance of 191 feet in the longest instance, aided probably to a certain degree by air currents. No doubt they would pass through greater distances, but there was no opportunity to observe any instance of it.

These observations deal with only one or two species of mosquitoes and are limited in number and circumstances, but if they should be generally true under conditions ordinarily met with in antimosquito work, then they have an actual practical value.

In accordance with these facts it seems unnecessary to screen waterspouts and other pipes into cisterns and similar deposits of water when such pipes have a considerable horizontal section. The saving in this way of time, labor, and materials may be quite appreciable. However, the screening of such openings will be required in those instances where mosquitoes are breeding from eggs carried into the water from an outside place of deposit.

Sewers, cesspools, etc., may be breeding places of certain kinds of mosquitoes, and their possible passage for considerable distance up the soil and drain pipes must be considered. Such pipes are usually trapped near the sewer or cesspool, but not always, especially in old constructions and in localities where plumbing laws are lax or nonexistent. It is probable that the most important antimosquito work is done in the smaller towns, villages and isolated houses, where local deposits of water are apt to be found in place of a piped water system.

A New Theory of Magnetism

In the Science Reports of the University of Sendai, Prof. K. Honda and Mr. J. Okubo give a new theory of magnetism which agrees more closely with the observed facts of para- and dia-magnetism than any previous theory. According to it, the molecular magnets rotate about axes not in general coincident with their magnetic axes. The component of the magnetic moment of a molecule along the axis of rotation the authors call the axial, and that at right angles the transverse, component. When a magnetic field acts on the molecule, precession and nutation take place owing to the axial component of the magnetic moment. The nutation is damped out by thermal impacts among the molecules, but the precession continues at an angle which implies increase of magnetic moment in the direction of the field, and the effect is paramagnetic. The transverse component of the moment causes the rotation of the molecule to be faster when that component is in the same direction as the field, and to be slower when in the opposite direction. The time mean of the effect is therefore in the opposite direction to the field —that is, it is diamagnetic. The preponderance of one effect over the other determines the para- or diamagnetic character of the material.

Wearing and Antifrictional Qualities of Cast Iron

Wear in commercial grey cast iron appears to be brought about by a process of surface disintegration, individual grains of hard eutectic being detached bodily. This débris may be largely instrumental in bringing about "seizing" in moving parts. Subsequently to this stage the plastic constituents flow into the cavities formed, and yield a well-glazed surface of excellent antifrictional qualities, with harder particles standing up in slight relief. The iron should not be too "open" in texture. There does not appear to be any relationship between wearing properties in cast iron and its Brinell hardness. The casting temperature of the iron is said to affect the antifrictional qualities, but in what way is not stated. Two machines designed to afford laboratory tests on the wearing properties of samples of cast iron are described.—*E. Hurst. Iron and Steel Inst.*

Fluorescence—II*

The Phenomenon of "Optimum" Fluorescence in Relation to Molecular Transformation

By Professor Jean Perrin

[Concluded from Scientific American Supplement, No. 2254, Page 163, March 15, 1919]

Remarkable independence with respect to temperature:—As I have demonstrated, molecular fluorescence is, at least approximately, independent of the temperature. Since this fluorescence marks the destruction of the body it is probable that the fragility of the molecule with respect to light and the emission of transformation are independent of the temperature.

This is particularly remarkable with regard to the rapidity of destruction, which is consequently independent of the temperature, like the fragilities. It is a well known fact that the rapidity of chemical transformation is generally sensitive to very slight variations of temperature. In the interval here examined, that between the temperature of liquid air and that of boiling water, the ordinary rapidity of the action would become a hundred thousand times as fast. We find here a second analogy with radio-activity. This indifference to the temperature exhibited by one class at least of the reactions provoked by light deserves attentive consideration. We shall shortly see that it can be generalized.

We are obliged to believe that the light destroyed within the molecule the rigid bonds upon which, in the domain under consideration, variations of temperature have no effect, and we may here recall that it is precisely this kinetic theory of specific heats which regards molecules as structures connected by perfectly rigid bonds.

May we hope to obtain a direct perception of the disappearance of fluorogene molecules?—We are now in a position to discuss the question put by me at the beginning of this article: May we hope to be able to obtain a direct perception of the molecular structure by means of fluorescence?

To begin with, there can no longer be any question of perceiving, by means of this phenomenon, either intact molecules or fluctuations in the concentration of molecules. All that we may hope to behold is the emissions of disappearance, or even, perhaps, merely their fluctuations of distribution.

We must seek fluorogenes which have the greatest degree of luminosity for a given illumination, and the smallest degree of fragility, so that the emission of the disappearance will be as great as possible. Of all the substances which I have examined Magdala rose seems to be the best adapted. A rough calculation based upon impressions which are not as yet suported by measurements gives 10-12 erg for the emission which accompanies each disappearance of a molecule. A value of such a degree of magnitude scarcely permits us to hope that we shall ever be able to perceive, in the dilute solution examined under the microscope even by taking every possible precaution,[12] a spot which is irregularly luminous because of fluctuations of fluorescence, instead of the usual homogeneous spot.

How is the concentration of the fluorogene molecules able to increase their stability?:—It remains to attempt to comprehend why the destruction by light of the fluorogene molecules becomes less frequent as the molecules draw nearer to each other, a property which explains, as we have seen, the singular phenomenon of the optimium fluorescence.

Let us imagine a pencil of exciting light which traverses a thin layer of a fluorescent solution. I assume to begin with that this solution is very dilute, so that the chances of destruction of any molecule are certain not to be influenced by the other molecules (we have seen that this is absolutely true beyond a certain degree of dilution). If the light were homogeneous, and if all the fluorogene molecules were in the same state, they would all be destroyed at the same time, which is not the case. The meeting between light and the fluorogene molecule is not of the same character in the case of each molecule: there are *effective* meetings and meetings which are without effect. And at any given instant the proportion of molecules in a state of efficacy in this respect is extremely slight—otherwise the destruction would be extremely rapid.

In my opinion an effective meeting has the following characteristics: by means of *resonance, i. e.*, vibration in sympathy with the exciting light, there is set up in the molecule a vibratory motion whose amplitude gradually increases until it is sufficiently great to produce some sudden rupture, as a result of which the molecular or the atomic structure, having completely lost its equilibrium, takes on a different kind of conformation. This rearrangement is accompanied by a radiation which constitutes the emission of fluorescence, but which rapidly dies out.[13]

Let us suppose now that the solution acquires a considerable degree of concentration. In this case the fluorescence diminishes or ceases to manifest itself. The explanation of this fact is that the chance meeting of light and the fluorogene molecule which would have been effective if there had been no other fluorogene molecules in the vicinity fails to be effective by reason of such vicinity.

We are obliged to believe therefore that the molecule exerts less energy in the exciting radiation, so that the critical amplitude of the internal vibratory motion is not attained. This can be explained in at least two ways.

Possibly the considerable amount of absorption which permits the rupture to take place depends upon an accidental local increase in the density of the luminous energy[14] and not upon a particular state of the molecule. In this case, if there are other fluorogene molecules in the immediate vicinity of the first one they will absorb a part of the energy, and there will not be enough of it left to cause the rupture. The absorption of light which produces the color of the solution persists, but the method in which this energy is utilized is changed.[15]

Or else, according to another hypothesis, the very considerable degree of absorption which occurs depends upon some very special accidental state of the molecule. In this event the other molecules would not be directly absorbed, even if very near the first one. But the mass put into vibration in the sensitive molecule would exert a sort of "induction" upon the similar masses of the neighboring molecules, which would cause these to vibrate in their turn, through a secondary sympathetic vibration; and the nearer the molecules were to each other the more active this induction would be. And furthermore the effect of this action would be to distribute among a number of molecules which remained intact the energy which would have been required to break up and reconstruct irreversibly a single one.

According to either hypothesis, and without doubt according to any hypothesis at all which is capable of explaining the optimum, it is evident that stabilization depends upon a *physical* distribution among a number of molecules of the energy which would have been required to effect a chemical modification. The domain within whose bounds a fluorogene molecule helps to stabilize another is obviously at first not very clearly defined. The process of stabilization begins when the molecules are at an average distance of 30 millimicrons from each other, *i. e.*, in a one-hundred-thousandth solution; it is practically complete when these fluorogene molecules occupying one-fifth of the volume of the solution are at an average distance of 1.5m μ.

Furthermore this value is variable, and more so with respect to the substance than as regards the length of the exciting wave. In the case of fluorescent blue, for example, which is very absorbent, the extinction has already become practically entire at a content of 2 per cent. corresponding to an average separation of the molecules of 4 m μ. In the case of this substance the protection is already quite marked at an average distance of 30 m μ.

The explanation of the optimum in atomic fluorescences or phosphorescences is to be sought for along the same lines. The average diameter of the domain in which the protective action is exerted is of the same degree of magnitude, *i. e.*, a few millimicrons.

Fluorescence in ultra-thin films:—This idea that the stabilization of a fluorogene molecule is due to the ensemble of the molecules of the same kind contained within the interior of a sphere of considerable radius finds a new verification in the apparatus which I will now describe and explain.

We are here no longer concerned with observations made upon films of liquid having a thickness of several microns, but with those having for their subject the "black spots" found upon soap bubbles containing 1 part of fluorescent blue in aqueous soap solution. In observing these I illuminated the layer formed obliquely in such a manner that only the light of the fluorescence could enter the microscope.

Three varieties of black spots with clearly defined borders and practically constant thicknesses[16] were identified, the latter being approximately equal to 6 m μ, 10 m μ, and 15 m μ. Red fluorescence disclosed itself upon all these black spots, and upon the film (whose thickness varied from a tenth of a micron to a micron) being fainter upon the black spots than upon the film. But among these three black spots the middle one, as regards thickness, was the most brilliant, the thinnest one came next and lastly the thickest one.

The explanation is quite obvious. In the case of an extremely thin film, of the degree of magnitude of a millimicron (if we were capable of making such a one), one much thinner accordingly than the domain of protection, a fluorogene molecule has practically no protection at all. Let us now increase the thickness: in this case the luminosity will increase, but less rapidly than the thickness, for stabilization begins to make itself felt.

Let us now increase the thickness once more: the stabilizing increases and may get the upper hand, so that the luminosity will decline. Again we increase the thickness: the stabilizing effect will not attain its maximum value. After the moment at which this occurs the only influence which can be exerted by increasing the thickness still further will be to augment the luminosity. And this is what occurs, as a matter of fact.

Photo chemistry:—As we have seen in the explanation just given fluorescences are characteristic of a still unknown group of reactions occasioned by light. But certain reactions excited by light which are undoubtedly chemical in nature, and none of which is accompanied by fluorescence (at any rate by visible fluorescence), have long been studied under the name of photochemistry.

It would seem to offer much of interest to compare these two groups, taking as the governing idea the investigation as to the extent to which the laws of one group are operative in the other. Features deserving of special attention are the influence of temperature and that of concentration in photo chemical reactions—in seeking to discover, for example, whether there exists any of the stabilizing effect due to the coming closer together of the molecules.

It is my present opinion that it is entirely possible that the chemical action of light may be quite independent of temperature. The cases in which a marked dependence upon temperature has been pointed out appear to be explicable by the intervention of secondary phenomena (diffusions) which alter the degrees of concentration in the illuminated layers in a manner which varies according to the temperature. In the case of photographic films, on the contrary (in which diffusion does not occur) the measurements which have been made appear to prove that the temperature of the film exerts no influence whatever upon the time of exposure.

Furthermore, I expect to demonstrate shortly the possibility that the action of light, governed by laws analogous to those which we have just examined, dominates the entire realm of Chemical Mechanics.

*Translated from *Les Annales de Physique* (Paris) for the Scientific American Supplement.

[12] Carefully eliminate dust, whose luminosity seriously disturbs ultramicroscopic observation; illuminate for a very short period; observe with a thoroughly rested eye.

[13] By way of simile, it is in this manner that by means of a periodic excitation in sympathetic vibration with the period of the string of a strongly bent bow, one can cause this string to break, in which case the bow will assume the "extended" form, after a series of vibrations (having no relation to the period of the first vibrations) around this second form. The string may suggest a valence.

[14] This occasions the intervention of fluctuations of energy in the interior of a ray of light. That there are such fluctuations is not to be doubted, but their average value in a given time in an element of given volume is, I believe, entirely unknown, even as a degree of magnitude.

[15] P. Curie directed attention to the fact that we are totally ignorant as to how the energy absorbed as a consequence of color is transformed into molecular thermic agitation.

[16] In an article to appear shortly I will examine in detail this subject of the stratification of liquid films.

Replacement of Platinum in Apparatus for Electrolysis

Electrodes made of alloys of gold and platinum containing from 12.5—25%Pt were found to vary in weight during electrolysis of certain solutions. The authors recommend the use of an alloy of gold, silver, and copper in the proportions of 920:50:30, the electrodes being coated with a thin layer of platinum (0.005 grm. per sq. cm.).—*Note in J. Soc. Chem. Ind. on an article by P. Nicolardot and J. Boudet in Bull. Soc. Chem.*

Trees for the Desert

Uncle Sam to Re-Forrest Barren Areas

By Arthur L. Dahl

Uncle Sam believes in putting everything to its best use. At the present time there are 5,600,000 acres of barren public lands which are best suited to the growing of trees, either for timber or water conservation. Because of fires, intensive lumbering, or other causes these lands have been denuded of tree growth and conditions are not favorable for the natural reforestation of the areas through seed trees. Accordingly, the Government Forest Service is using the resources at its command to replant certain portions of these lands where growing and soil conditions are most favorable or the need most urgent. Every known method of reforestation is used and experiments are being carried on in different parts of the country to discover new or better ways of producing results. When the experimental work done in a certain locality shows that planting can be successfully carried on, the operations are carried out systematically and scientifically on a large scale. Local needs and conditions are carefully studied, however, before this work is commenced, as the species selected for, and the methods of planting used on, the treeless plains of Nebraska or Kansas would not be suitable for the fire-swept sides of a mountain in California or Montana.

Nine-year-old stand of Douglas Fir planted after a Washington forest fire

It is the object of reforestation to improve thin stands of timber and to make the bare lands productive. In carrying out this object the Forest Service annually plants from 12,000 to 15,000 acres.

With the area of the lands suitable for reforestation running into the millions of acres, while the planting operations of the Government are confined to but a few thousands of acres, it is essential that the reforestation work done be restricted to those localities which promise the greatest returns, either in timber or protection. On the other hand, the experimental stations of the Forest Service are scattered over as wide an area as possible, with the idea of securing as much first-hand information about species, growing conditions, and tree enemies as can be learned in different parts of the country. In addition to the large central nurseries maintained for the propagation of millions of seedlings for use on the National Forests, hundreds of smaller ranger nurseries are maintained near the cabins of the rangers, where they can be watched by the men without seriously interfering with their regular duties. In many forests, the principal duty of the rangers is to patrol for fires, and on cloudy days or after local thunder showers which occur in the higher mountains, there are periods when the men stop their patrol work and put in their time working in their nurseries. As ample water is usually available at the ranger stations, very little attention need be given the growing trees until the time for transplanting is at hand, and in this way large quantities of seedlings are grown locally and transplanted during the winter season to nearby barren sites. The fact that the ranger has raised the seedlings from seed, and watched the tiny trees develop, inclines him to take more than usual interest in seeing that they are properly transplanted and protected until such time as their roots have become firmly fixed in the soil.

Another way in which the Government endeavors to reforest the public lands is to supervise the timber cutting in commercial stands of timber and prescribe that certain designated seed trees be left standing to insure suitable seed for natural reproduction. Furthermore, all small trees, not suitable for lumber, are protected and the great waste characteristic of old-time methods of lumbering is thus done away with.

The actual work of reforestation done by the Government is carried on in one of two ways, either by sowing the seeds of desirable species, or by raising seedlings in nurseries and transplanting them. In selecting sites for artificial reforestation preference is usually given, first, to watersheds of streams important for irrigation and municipal water supply; second, lands which will produce heavy stands of quick-growing timber of high commercial value, such as in northern Idaho and western Washington; third, regions where the supply of timber is limited and more wood is needed for local uses, as in the Dakotas, and fourth, sites which offer good opportunities for object lessons in the practice of forestry, such as the sand hills of western Nebraska.

As thousands of pounds of tree seeds are needed by the Government in carrying on its work, and the quality of those seeds largely influence the results obtained, the Forest Service uses its own organization, as far as possible, in the collection and preparation of the seeds needed. Trees, unlike most other plants, do not produce a good crop of seed every year. A few cones are produced each year, but with most species it is only at intervals of from two to five years that a heavy crop occurs. These periods are known as "Seed Years" and at such times greater effort is made to secure a suitable supply to provide for the lean years. As squirrels consume large quantities of tree nuts the supply during off years is difficult to get and is quite expensive work.

Cones of most of the pines take two years to mature. Those of some of the junipers and cypresses also take two years, and a few require three years. It is often possible, therefore, to predict a crop of any of these species in advance. The Forest Supervisors are instructed to report the localities where abundant seeds are available, and special parties are then made up to gather the harvest. Cones are collected from felled trees, from standing trees, and from squirrel hoardes. Where logging is going on it is often possible to pick the cones from the felled trees and from the ground surrounding them. Where the trees have to be climbed, one or two members of a party will knock off the cones by poles or hooks, while other members of the party gather them from the ground. They are usually placed in sacks and shipped to plants designed to extract the seeds. Squirrel caches are usually the most prolific sources of seed, as the industrious creatures store not only what they need for their winter supply, but large quantities in excess of that. As much as 8 to 12 bushels of good cones have been taken from one red squirrel cache, though the average quantity found is about 2 bushels.

With the exception of lodgepole pine, the cones of most trees can be opened by drying and exposure to the sun, thus securing the seeds. A succession of clear, sunny days and frosty nights will open cones very rapidly, and by spreading out the cones on canvas and protecting them from moisture, the seed can be obtained in from 4 to 10 days.

Seeds are also extracted from cones by subjecting them to artificial heat, either in rooms kept at a uniform temperature by means of an ordinary stove, or in specially designed plants capable of handling large quantities each day. In Colorado, for instance, the Government maintains a cone-drying plant which is used exclusively for extracting the seed from lodgepole-pine. The pine cones are collected in October and held in storage bins for 12 to 15 months before the seed is extracted. This plant can handle 108 bushels of cones a day, which produces from 40 to 45 pounds of seed. The empty cones furnish the fuel to operate the plant.

Of the two methods of artificial reforestation, direct seeding offers the easiest and cheapest solution of the problem. The seeding itself is a very simple operation and it can be carried on by inexperienced labor. Of 124,732 acres of reforestation work carried on by the Government up to 1915, 84,300 acres were seeded directly and 40,412 acres were planted. Practically all of the most important western species of trees and a number of exotics have been given a trial, a wide

Wholesale forestation of the Nebraska sand hills by means of fine seedlings

Present state of a yellow pine set out in 1906

range of conditions have been covered, and a great variety of methods tested.

The difficulties to be overcome under the direct seeding method, however, are numerous, and in many localities where tried it has not been a success. Birds and squirrels consumed most of the seed, in some instances, and where germination was secured, the seedlings were killed by droughts, frosts, or were eaten by animals. Not until a plantation has passed through a period of at least three years can it be said to be permanently successful. However, the result obtained in many localities, in comparison to the cost of operations, has justified the Government in continuing its work along this line. Consistent success in direct seeding has been obtained with lodgepole pine on the Arapaho National Forest in Colorado. Here, on northerly slopes at altitudes between 8,000 and 10,500 feet, broadcasting on the snow and seed spotting, have given good results. In Florida broadcast sowing has also been successful where the ground had previously been plowed, and the seed was covered by the operations of a brush drag.

In broadcasting, seed are scattered by hand or by the use of a mechanical sower in much the same manner as grain. The best results have been obtained by going over the entire area and sowing half the seed, then traversing the same area at right angles, sowing the remainder. This insures a more even distribution of the seed. Sometimes the ground is raked or harrowed, and it has been the experience of the Government that the greater the preparation of the soil the more successful is the operation. On the other hand, the expense is much greater, and often the topography is such that cultivation cannot be practiced.

Another method of the direct sowing is by seeding narrow strips three feet wide or less, leaving wider spaces between. This is done upon the theory that if the plantation is successful, natural reproduction will reforest the intervening areas.

In the seed-spot method small spots quite regularly spaced are more or less prepared for the reception of the seed. After the seed are sown on each spot they are covered with a thin layer of soil. By restricting the area to be covered more labor can be expended upon these seed spots, thus insuring favorable conditions for the seed during the germinating period. By using corn-planters more ground can be covered per man by this method than any other, except broadcasting.

The experience of the Government tends to prove that the most successful results in reforestation are produced by direct planting rather than the use of seed. Where operations have been conducted during the right season, and suitable stock is used, successful results have been obtained in over 75% of the work of the Forest Service. With the development of the Government nurseries and the increase in the areas devoted to the raising of seedlings, Uncle Sam is producing more than 10 million transplants a year, all of which are being set out on the public lands of the West.

The seedlings to be transplanted are raised either in the small ranger nurseries, ranging up to 200,000 plants annually, or in large central nurseries capable of growing millions of plants at one time. Here the seed are planted in specially prepared beds and the individual seedling is transplanted and nurtured to develop sturdy root systems and a healthy stem, so as to be capable of meeting the adverse conditions to be met with when finally transplanted in its future home. The time required to grow plants suitable for transplanting ranges from one to three years, depending upon the species used and the condition of the planting area. The object of transplanting the seedling in the nursery is to check its height growth and to stimulate the development of the feeding roots so that when it is planted in a less hospitable soil it will adjust itself to conditions, just as it did in the nursery.

When the plants are large enough to be taken to the planting area they are carefully dug up, leaving as much of the root system as possible. The trees are tied together in small bunches, and the roots carefully packed in damp moss, to prevent their drying out. Trees so prepared have been sent across the Pacific, and though more than a month elapsed before being planted, the root systems remained fresh and moist.

Arriving at the planting area the trees are "heeled in" unless they are to be immediately planted. This heeling in consists of digging shallow trenches in moist soil, in which the roots of the trees are placed and then covered over until such time as the seedlings are planted. During the period of transportation to the spot selected for their setting out, the trees are carried in buckets, with as much of the surrounding soil as will cling to the roots.

There are various methods used in planting the trees, the principal one being called the "Slit method."

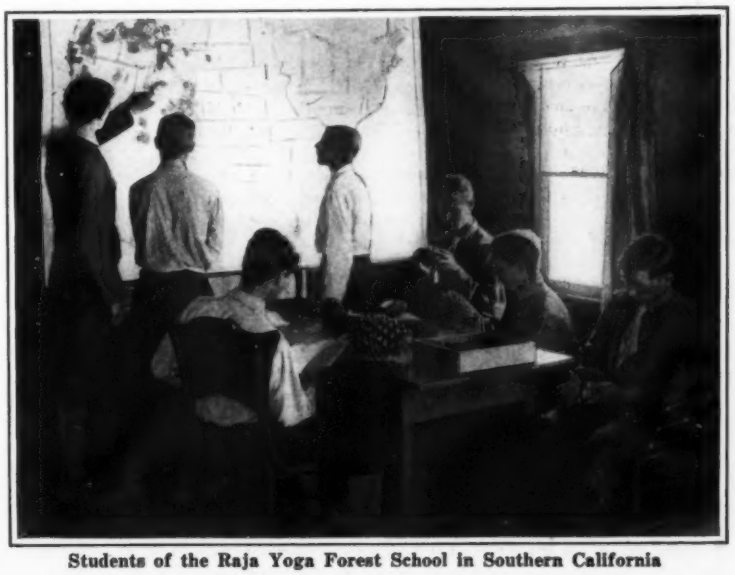
Planting operations in the nursery showing shade frames used over the beds

This consists of opening a wedge-shaped crevice in the ground by driving a spade, mattock or axe into the soil and moving the handle back and forth until a hole two or three inches broad at the top, as wide as the blade of the tool, and tapering to an edge at the bottom, is formed. Into this crevice the roots of a plant are thrust and shaken down, care being taken to see that the roots are not bent or cramped. The soil on each side of the hole is then firmed against the plant, and if water is available, a small supply is added.

Another method used in planting trees is the "Trencher method," which consists in digging a shallow trench along which the trees are planted, and the earth filled in. This method is only used where the character of the ground will permit the use of horses to dig the trench, but it has been found very satisfactory on the plains of Kansas and Nebraska.

The "Pit method" is designed particularly for use in regions where the seasons following planting operations become hot and dry. It consists in partially preparing the holes in advance of the planting operations. The earth is extracted from certain designated spots, after which it is replaced loosely, and a small depression left on the surface. Rain which will saturate the hard ground only to a depth of 2 or 3 inches will be sufficient to penetrate from 12 to 16 inches in the soft soil of the pits. Accordingly, the plant placed therein will have a reserve supply of moisture to draw upon during the succeeding hot season.

In most localities the planting operations are conducted during the spring months, but in southern California, on account of the long hot dry season so closely following the spring planting season, planting in the fall after the beginning of the rains is considered best.



Students of the Raja Yoga Forest School in Southern California

Effects of Hurricanes on the Upper-Air Currents

A SHORT note under the above heading appeared in the *Monthly Weather Review* for October, 1915, 43, 496-497. It was there shown that if we pointed a telescope to a bright star near the zenith, and then drew out the eyepiece 2 or 3 millimeters, so as to throw the image out of focus, a round disk of light would be obtained from which we could draw conclusions as to the condition of the upper air currents. In the temperate zone parallel lines crossing this image are not infrequently seen. They never appear in the tropics, however, unless some serious disturbance is at hand. They then lie in a direction parallel to the motion of the disturbance. In September, 1915, we were in this manner able to foretell a hurricane whose center was at a distance of 750 miles, some 20 hours before we received the Government notice of its presence, and two days before the center reached us. On Thursday, August 22, of the present year we received our first notice from the United States Weather Bureau of a disturbance located to the southeast of Barbados. On August 23 we were warned by the local bureau to take all possible precautions as the disturbance would probably reach us on Saturday morning. Friday night was clear, and we hastened to the telescope, but to our surprise not a trace of any hurricane lines could be found. The star image was "moulding," however—that is to say, it looked as if it were being moulded by the fingers first in one place and then in another. This indicates local atmospheric disturbances. The seeing was poor, 6, later dropping to 5 on a scale of 12, but was not extremely bad, such as is the case in the vicinity of a hurricane. We therefore retired considerably relieved, in spite of the warnings. The next day the sky was heavily overcast, but with no rain and only moderate winds, and we were informed by the United States Weather Bureau that there was no definite information as to the location of the disturbance. As it turned out the hurricane either had not developed or had taken a more northerly course.

From this we would conclude that telescope observations of the kind described are of value in the local forecasting of tropical storms, not only to foretell their approach and the direction of their motion, but also sometimes to inform us that other indications are not to be trusted.

Uncut Books Are Now Looked Upon as Back Numbers

MANY people wonder why it is that books are still issued with uncut pages. Such people may be lazy or may be very busy; but in either case they might like to have the interesting explanation by the publisher of *Science Progress*. He says:

"As regards uncut pages, there are very few books published nowadays with their pages uncut. For a fine book, I greatly prefer it in that form, as it leaves a margin of paper for trimming in the case of a book which one wishes to put into a good permanent binding later on. Moreover, for any one with leisure to read, I think it is a positive luxury to cut the pages with a good paper knife. I did this yesterday in the case of an old book which I had not taken from my shelves for a period of many years, and enjoyed it thoroughly.

Another objection to cut leaves in the old days was that certain people came into booksellers' shops and spent a long time there; in fact, they were able to get all they wanted out of a book without buying it! It was said that Southey could tear the heart out of a book by turning the leaves in a booksellers' shop. But now everybody is in a hurry, and uncut edges are gradually disappearing except in the case of fine books. I am sorry for it, but the uncut form must now be regarded as a 'back number.'"

Lunar Theories

A Heliocentric Suggestion That Calls for Some Attention

By J. Hardcastle

SEEING recently (not for the first time) in Flammarion's "Popular Astronomy" his diagram representing the courses of the earth and moon around the sun as long-drawn-out wavy lines, crossing and recrossing each other, with his accompanying statement that the course of the moon is everywhere concave to the sun, the humorous idea occurred to me that the motions of the earth and moon resembled those of two cyclists alternately "pacing" each other round an enormously long and narrow racing track. Such motions are entirely different from those usually ascribed to these bodies—the earth circling round the sun in an elliptical orbit, and the moon, so to speak, "running rings round" the earth in a smaller elliptical orbit. Struck by this difference of ideas, I set about inquiring whether the motions of the moon have been treated by anyone from the heliocentric or any other extra-terrestrial point of view; looking upon earth and moon not as planet and satellite but as a pair of planets traveling round the sun in company, and changing places as leader and follower under the influence of their mutual gravitation.

I have been able to find not even an illusion to such treatment of the moon's motions. It is not because the true motion was not known. There is Flammarion's diagram (first drawn in 1876 he tells us) and his accompanying remarks. These are explanatory of the diagram, not of the motions it represents. R. A. Proctor's "The Moon" (1st ed. 1873) also contains a diagram of a different kind, to illustrate his statement that the moon travels round the sun in company with the earth, her track being a "serpentine or wavy line." Proctor says the perturbations of the motions of the moon as a planet subject to the attractions of another planet—our own earth—could be easily tested. But he does not test them—does not treat the moon in that way. He insists that the sun always has nearly twice as much power over the moon as the earth has, yet he treats the earth as principal and the sun's attraction as a perturbing force merely; and throughout his minute treatise on the moon's motions he assumes that she travels in an elliptic orbit around the earth.

All the text-books, every encyclopaedia article and the like, that I have met with, explain the moon's motions as these are seen from the moving earth. In working out the moon's real motions as these would be seen from a viewpoint distant from the earth, I found the problem of the apparent circular movement so simple and so interesting that I felt surprise that this treatment has not been adopted in "popular" astronomies, if only as a supplement to the usual geocentric or "satellite" theory. The latter may be more convenient and more useful for the practical astronomer—I cannot say. It may be easier to account for the minor motions—the perturbations or irregularities in the principal motions—by the geocentric theory than by the other. I cannot say. I suspect the contrary, because the geocentric theory deals with appearances, and science, we are told, deals as far as possible with the realities behind appearances. As yet astronomy, as far as I can discover, has not attempted to do this in developing the theory of the moon's motions. It is stated that there are about sixty "anomalies" in the moon's motions, some of which have not yet been accounted for. A heliocentric lunar theory could scarcely involve more such enigmas. Proctor mentions one enigma that presents itself in the current theory, "If the sun has more power over the moon than the earth, why does it not pull the moon away from the earth at new moon?" Proctor's reply is a lame one, is no reply at all in fact, and it proves that he had not really thought of the moon as a planet subject to perturbations by the earth. Proctor does not deal with the principal motion of the moon, because "the phases of the moon are explained in text-books of astronomy."

"The earth goes round the sun in its annual journey of 365 days. The moon goes around the earth once every 27 days. The motion of the moon is thus a very complicated one, for it is actually moving round a body which is itself in constant motion." That is the explanation of the text-books, as stated by Sir Robert Ball, and he gives the moon's orbital rate as averaging 2,273 miles per hour. A very different notion is derived from a consideration of the moon's actual course in space.

The principal observable motions of the moon, as seen from the earth, are two. First, the familiar movement which is completed in a lunar month, or lunation, which results in an apparent circuit of the earth, and in the production for us of the moon's "phases." It will be convenient to refer to this later as the "phase movement." Second, the movement in latitude, or northing and southing. Everyone has observed this, if only to the extent of noting that the full moon is sometimes nearly overhead and sometimes low down in the north, at midnight.

For the principal movement, that which causes the moon to appear to travel round the earth, the facts or data we have to work with are:—(1) The mean distance between earth and moon is about 60 times the earth's radius or semi-diameter, or 238,000 miles. (2) The earth's mass, gravitating or pulling power upon other heavenly bodies, is 80 times that of the moon, so that in a given time their mutual gravitation could move the moon towards the earth 80 times as far as it could move the earth towards the moon. (3) Consequently, from (1) and (2), the earth could pull the moon over the distance separating them in the time required by the moon to pull the earth over three-fourths of the latter's radius. (4) The mean rate at which earth and moon travel round the sun is 46 million miles per lunar month. (5) Earth and moon travel round the sun in a circular twin orbit, and are therefore subject to centrifugal force tending to take them away from the sun, this force therefore counteracting the sun's pull upon them towards itself. Acceleration of orbital rate increases, and lessening of that rate decreases, the centrifugal force. (6) The increases and decreases of orbital rate we have to deal with are but small fractions of that rate, in the case of the moon about one-fiftieth, in the case of the earth a quite minute fraction. (7) Both earth and moon describe wavy lines in their journey round the sun. A nearly pure circle is traced by the common centre of gravity of the two bodies, and that centre lies within the earth, on the line adjoining the centres of earth and moon, about three-fourths of the radius from the earth's centre when the moon is at its mean distance, and shifting 110 miles or so inward or outward with the moon's least and greatest distance, but always remaining within the earth. I will call the curve traced by that common centre of gravity the E.M. orbit. (8) In considering the phase movement in a general way the gravitational pull of the sun upon the earth and upon the moon may be assumed to be a constant quantity; and variations of the moon's distance from the earth, and the northing and southing of the moon may be ignored. The daily rotation of the earth and the monthly rotation of the moon do not enter into the problem of the phases.

Starting with the moon at first quarter, with both earth and moon centred on the E.M. line (as sometimes happens) the moon is then following the earth at her mean distance, and both are, for the moment, travelling on the E.M. line at the same rate of 46 million miles per lunar month. In these positions the earth pulls the moon forward, increasing her solar orbit pace, and the moon pulls the earth backward, reducing its pace, the effective action of each upon the other being in proportion to their respective masses, i. e., 80 to 1. These interactions continue for a week, in which time the moon has been drawn forward so that she overtakes the earth at full moon. The earth's gravitational effort has been to pull the moon to itself, but the increase in the moon's pace caused by this effort increases the moon's centrifugal force in the solar orbit, and this throws her further out from the sun, so that she passes the earth, at full, on the outside of the E.M. orbit. The acceleration and the centrifugal force are so nicely balanced that the moon maintains an approximately equal distance from the earth during the week, and she passes the earth almost as far away from it as she was at first quarter. The backward pull of the moon reduces the earth's orbital rate and its centrifugal force, so that the sun is enabled to draw the earth inward, to the extent of three-fourths of the radius. (This follows from the fact that the common centre of gravity of the two bodies describes the common solar orbit.) Three-fourths of the earth's radius is also the measure of the amount the moon was able to retard the earth's progress in that week.

After the moon has passed the earth at full, and onward for a fortnight to new moon, opposite reactions take place. The earth pulls the moon back, reducing her rate and centrifugal force; the moon pulls the earth forward, increasing these elements in its case. The acceleration of the moon's rate between first quarter and full moon carries her ahead of the earth, but immediately she gets ahead the earth's pull becomes a brake, in a week deprives the moon of her acceleration, and reduces her centrifugal force so that the sun draws her inward to the E.M. line at last quarter. At this point the moon is still ahead of the earth, and the brake action continues to slow down the moon so that the earth passes her at new moon. The sun meanwhile, acting upon the moon's lessened centrifugal force, has drawn her inward to the moon-earth distance inside the E.M. line at new. During the period from full to new moon the earth is drawn forward, its orbit rate is slightly increased, and consequently at new moon the centre of the earth is outside the E.M. orbit by three-fourths of the radius.

After new moon their mutual gravitation accelerates the moon's and lessens the earth's rate, consequently the moon swings out to the E.M. line at first quarter, our starting point, and the earth swings back to centre on that line.

The alternate accelerations and retardations of her solar orbit rate cause the moon, in passing from first to last quarter, to travel nearly half a million miles (twice the earth-moon distance) further than in the other half of the lunation; for, starting at first quarter that distance behind the earth, she is at last quarter the same distance ahead of the earth; and these gains are lost through her slower pace between last and first quarters. During each lunation the earth alternately gains and loses pace, at times opposite to the gain and loss of the moon, to an extent of twice three-fourths of her radius, or about 12,000 miles.

It must constantly be born in mind that these changes in pace, resulting in changes of relative position, are but small fractions of the enormous orbit rate of 46 million miles per lunation; and that each increase and decrease is spread, though unequally, over a fortnight. It must also be borne in mind that the curves traced by the moon in swinging outward from the sun differ very little in curvature from the E.M. orbit, because they are about a hundred times as long as the extreme width separating them from that orbit. If we draw part of a circle with a radius of 92 inches (it can be done with a bit of twine and a pencil) and cut off a segment of it with a line about 59 inches long we shall have an arc of about 30 degrees, and 60 inches long, representing a month's course of the E.M. centre of gravity. If we would add the moon's course along this arc in due proportion, we must draw the two curves, outer and inner, so that their extreme distances, at full and new, from the E.M. line, are but little more than one-third of an inch from that line. It will be seen at once that the moon's course is always concave towards the sun, and consequently that centrifugal force is always acting effectively upon the moon.

For a time I wondered, and others may wonder also, if the moon has to travel faster to overtake the earth, and then to slow down to allow the earth to overtake her, why these differences of rate are not clearly perceptible in the apparent movements of the moon. As one friend said, "The moon has to go 'eyes out' to overtake the earth, and we ought to see that." Such wonder arises from forgetting that the overtaking of the earth is spread over a week, and that the increase of distance travelled is but a small fraction of the total journey in that period. As a matter of fact the swifter and slower paces of the moon are observed, measured and calculated in advance, and given in the almanacs under the heading "Right Ascension at Noon," for each succeeding day. Comparison of the differences between successive pairs of these numbers shows where the accelerations and retardations occur.

To sum up this part of the subject: It appears to me that the monthly changes in the moon's position in relation to the earth and sun—the phase-making movement—are explained by referring them to alternate increases and decreases in the centrifugal force in her solar orbit, due to the attraction of the earth alternately increasing and decreasing her solar orbit rate, the opposing forces being so well balanced that the moon maintains an almost constant distance from the earth. (The difference on either side of the mean distance is at most one-fourteenth.) The result is that, as seen from the earth, the moon appears to travel round the earth only.

Reverting to the cyclists "pacing" motion, it is now clear that this will not do. Luna does some pacing, and Tellus feebly responds to the invitation to "come on," but when Luna has dropped back to the rear to give Tellus his turn, he also slows down. Tellus in fact, maintains an almost even pace in the middle of

the track. Luna races up, passes on the right, gets ahead a little, then slows down, and, observing the rule of the road, allows Tellus to pass her, and she falls back as far to the rear as she had previously been ahead. That it is not a case of Luna "running rings round" Tellus will be seen from the fact that the proportions of their monthly course may be likened to a cycle track, slightly curved, two miles long, and, to give plenty of room, 120 ft. wide, on which two cyclists travel together. One of them, the bigger, Tellus, has a start of 60 ft., and rides in the middle of the track all the way. The other, Luna, overtakes Tellus at the half mile, and having swung out to the right-hand side of the track passes him. At the end of a mile Luna is 60 ft. ahead of Tellus, and in the middle of the track. In the second mile Luna slackens her pace, swings across to the inner side of the track, Tellus passes her at the half mile, and at the end of the two miles that represents the month's course, Luna is again 60 ft. behind Tellus. This is the true order of their going, month after month, as far as concerns the apparent circling round the earth and the phenomena of the phases. The "elliptical orbit" is but the special terrestrial view of that order. An eye placed high above the plane of the earth's orbit would see it very differently, and as here set forth. It follows, therefore, that the Man in the Moon could frame a theory of the motions of the earth, as seen from the moon, on all fours with our current lunar theory. He could say that the earth moved round the moon in an elliptical orbit, having the moon in one of the foci of the ellipse. That would be his explanation of the earth's phases and differences in the apparent size of the earth, and other conditions would be given associated explanations.

The phase movement of the moon, considered separately from other movements, might be confined to the ecliptic or plane of the earth's orbit. In that case, to an observer on the sun the fortnightly excursions of the moon inside and outside the E.M. orbit would not be discernible, except by change of apparent size with change of distance. The moon would appear to travel on the same track as the earth, alternately leading and following, alternately passing backward in front of the earth, and forward on the further side.

The second of the moon's chief motions, her northing and southing, or swing in latitude, similarly considered as if it alone existed, is visible to a supposed observer on the sun, as a wavy line, running in a very flat curve for a fortnight above (north of) the earth's track, and then in an equally flat curve for a fortnight below (south of) it. These curves are shorter than the phase curves, as 12 to 13—42½ million miles for each pair, as against 46 millions. The width of the curves is very much less. The phase curves run out to 238,000 miles as a mean and 253,000 at the maximum, while the latitude curves at most run out to about 22,000 miles, or less than one-eleventh of the other's maximum, and less than three times the earth's diameter. It takes the moon 29.53 days to run a pair of phase curves; a pair of latitude curves are traced in 27.212 days, say 2.3 days less.

This swing in latitude is a true "swing," a pendulum-like movement. Starting slowly from each extreme, north or south, it increases in pace till the ecliptic is crossed, slows down to the other limit and then slowly starts back again. The almanacs, in their tables of "declination of the moon at noon," foretell the position of the moon in latitude for each day, and comparisons of the daily changes show that this is the nature of the movement.

The geocentric theory explains that this swing in latitude is a consequence of the moon's orbit being "inclined to the ecliptic," by a fraction over five degrees. The "declinations," however, usually reach over 28 degrees. This is because to the inclination of the moon's orbit is added the inclination of the earth's axis to the ecliptic, 23½ degrees. The moon's "tropics" on the earth are therefore 57 degrees apart, and at some part of each lunation the moon reaches further north or south on the meridian than does the sun at midsummer, and descends lower than does the sun at midwinter. It is important to bear in mind that the moon's share in the total declination is only 5 degrees on each side of the ecliptic, or working in the fraction over, about 22,000 miles north and south of the ecliptic. In a diagram representing the earth by a circle 5¾ inches in diameter, with axis and equator drawn at an angle of 23½ degrees to a horizontal line drawn through the centre representing the ecliptic, one line above and one below the ecliptic line, parallel with and a quarter of an inch from it, would represent the field of the moon's swing in latitude.

Both sets of curves, phase and swing, being traced by one body, they must next be conceived in their combination. As a complete oscillation to and fro in latitude takes less time than a lunation or phase series (as 27.2 days is to 29.5 days), and therefore extends over a shorter length of orbit (as 42½ million miles is to 46 millions) the crests of successive latitude curves occupy different positions among the phase curves. The swing sometimes carries one phase, sometimes another, to its extreme north and south of the ecliptic. When the southern swing in latitude coincides with the extreme outer movement of the phases our full moon is high on the meridian at midnight. When the southern swing coincides with the extreme inward movement our new moon appears far south of west, having travelled during the day high in the sky, and the next full moon will be low down in the north. The north or south swing may be completed when, in the absence of this motion, the moon would be on the E.M. line, that is, at a quarter, and in these cases that quarter will be high in our sky, and the next, preceding and following, will be low. A series of such changes is gone through in a year, therefore they are seasonal, though not precisely true to calendar dates, the difference being about the same as with the dates of the "moveable feast" of Easter. Proctor points out that the fact of these positions of the moon being seasonal ought to put an end to notions that the moon has any special influence on the weather.

It is quite easy to mentally visualise the phase movement and the swing in latitude movement separately, but the combination of the two sets of curves, at right angles to each other, of different lengths, and of very different curvature, results in a curious much flattened spiral around the E.M. line that requires much patience to follow through successive months. The spiral is so flattened that its thickness, so to speak, is less than one-eleventh of its width.

Astronomers in their investigations of the complicated motions of the moon take note of several "periods" and related "orbits." One orbit is defined by its production of the phases, another by its inclination to the ecliptic, which results in the northing and southing, a third is the orbit which is elliptic and has the sun in one of its foci. All these orbits have different "periods." The elliptic orbit is taken to be the principal orbit, probably because astronomers first began with calculations of the moon's varying distances, and other orbits are worked upon as the results of perturbations. An interesting fact comes out on considering the differences among the periods. As seen from a distant star the moon completes a rotation and a revolution in a "sidereal" month of 27.322 days; a series of phases is completed in a "synodical" month of 29.53 days; the orbit which is inclined to the ecliptic is traversed in a "nodical" month of 27.212 days; the orbit which is the ellipse with the earth in one of its foci is traversed in an "anomalistic" month of 27.55 days. There is also a "tropical" month, a small fraction shorter than the sidereal month. A little simple arithmetic shows that thirteen sidereal periods give an (approximate) year of 355.16 days; thirteen nodical months a year of 355.16 days, thirteen anomalistic months a year of 358.16 days; and twelve synodical months a year of 354.36 days. These (approximate) lunar years are all shorter than our solar and civil year of 365¼ days. The point I wish to draw attention to is this. If earth and moon travelled in a straight line instead of a circular one, other conditions of their journey remaining the same, there would be thirteen phase months in the year instead of twelve, and the phase movements would keep step with the swing movements, if not absolutely, then very nearly. Earth and moon, however, travel in a circular course, not a straight line, and also slowly gyrate about their common centre of gravity, like a pair of waltzers going round a room. The consequence in both cases is to the performers' loss of count of one gyration. The dancers would count one turn less than a spectator in the balcony would see. The law that a revolution around a centre (whether the course be a circle or of any other form) is equivalent to a rotation about its own centre, has many familiar applications. A garden hose, for example, is twisted in coiling it, and one must get rid of that twist by twisting the hose in the opposite way. Binder twine is a very slackly spun cord, and the twist in it is visibly tightened if it is wound round a small thing in one direction, and visibly loosened if wound in the opposite direction. In the case of the earth and moon the loss of a sidereal month is spread throughout the year, and results in each phase month being lengthened by one-twelfth of the missing month, and twelve phase months become approximately equal to thirteen sidereal or nodical months. This loss of count from within of one revolution counted from outside the system affects the earth and the moon individually. Seen from without, the earth makes 366¼ rotations in our year of 365¼ days.

As this movement in latitude, considered as an independent movement, is performed at right angles to the pull of the sun, so that this pull cannot be its cause; and as the principal action of the earth produces the much larger phase movements, the swing in latitude must, I think, be due to some special influence exerted by the earth. The regular periodicity of the swing implies a like periodicity in its cause, that is, the force must be applied at intervals as regular as those of the swing. A familiar illustration of this is the child's swing. One pushes it, not continuously, but at intervals, and to be satisfactory the pushes must have the same intervals as the swings. As the motion of the moon in latitude is of the nature of a swing and the moon, balanced between the pulls of the sun and the earth on the one hand and her centrifugal force on the other is free to be moved, a very small force, regularly applied, would suffice to start and maintain such an oscillation. Now it is found that the unequal pull of the moon on the nearer and further halves of the earth's "equatorial bulge" has an important effect upon the earth. I cannot work it out; but it seems probable that the moon's swing of 5 degrees in latitude is caused by the reaction of the earth's equatorial bulge—her retaliation, for the moon's plucking at her girdle. The diagram above specified can be usefully applied in this connection, in order to see how the nearer half of the bulge in certain positions must pull upon the moon at a different angle from the earth as a whole, which is considered to exert its force as if this were concentrated at its centre. Of course any part of the earth's gravitating force applied to produce the swing in latitude must by so much reduce the total that, in the absence of the swing, would be devoted to the phase movement. As far as I can make out the action suggested is at mid-summer and mid-winter most effective at new and full moon; at the equinoxes (spring and autumn) at the quarters; and mid-way between solstace and equinox at the octants of the moon. The latter positions would not be as favorable as the first two, but they provide twice as many opportunities for the pull of the earth's girdle. That the swing in latitude is due to the earth only, and to a cause that acts regularly with each true (sidereal) revolution, is seen in the fact that there are thirteen to and fro oscillations in latitude in the lunar year. The cause suggested must act on the whole at right angles to the plane of the earth's axis (which is always parallel with itself) and at right angles to the ecliptic; hence its effects conform in number with the sidereal not with the solar, revolutions, and are not involved in the loss of count that affects the phase series.

Other points might be touched upon, but these are secondary, and this essay is not an attempt to produce a complete theory but merely an attempt to show that the motions of the moon can be studied from an extra-terrestrial viewpoint with interesting results. Whether this can be done usefully or not for astronomical science it is for astronomers to say. There seems to be a confession of need for a new method of attacking the problem in some remarks by Professor Simon Newcomb, a well-known American astronomer, author of the article "Astronomy," in the "Encyclopaedia Britannica." Professor Newcomb says:—"The mathematical theory of the moon's motions does not yet form a well-defined body of reasoning and doctrine, like other branches of mathematical science, but consists of a series of researches extending through twenty centuries or more, and not easily welded into a unified whole. Although the precision of the mathematical solution has been placed beyond serious doubt, the problem of completely reconciling this solution with the observed motions of the moon is not yet completely solved." Professor Newcomb's words, "beyond serious doubt," suggest that he, who had devoted much time to lunar problems, had some doubt about the soundness of the current theory. At all events, if no one has yet attempted to develop a heliocentric theory the incompleteness of the geocentric theory is a good reason for competent hands giving the former a trial.

Gas for Raising Steam

(*Continued from page 179*)

temperature of nearly 500 deg. In fact, the flame temperature, under such conditions, is so near to the ignition temperature of carbon monoxide that great difficulty might be experienced in burning the gas even with the smallest excess of air. Thus it appears fairly evident that sensible heat must be sacrificed, and with it a portion of the calorific power, in order to obtain a high flame temperature and certainty of ignition.

EXCESS AIR.

The most serious losses occur through the admission to the boiler of any air in excess of the minimum amount required for the combustion of the gas, the excess quantity reducing the flame temperature and

interfering with the transfer of heat, besides carrying to the chimney much heat which should be usefully employed. The scientific method to follow in burning gas is to utilize an arrangement or burner which gives complete control over the conditions of combustion. The ordinary efficiency of gas-fired boilers, under present conditions, is from 50 to 60 per cent., although many installations working on blast furnace gas show an efficiency of only some 30 per cent. American and Continental practice has proved that the most effective combustion takes place when gas and air are intimately mixed before combustion begins. To obtain the most intimate intermixture of air and gas either the gas or the air should be under a pressure of not less than two inches of water, or induced draught may be used. It is, however, preferable, unless the boiler brickwork is enclosed in sheet metal, to use pressure at the burners, for this prevents any serious leakage of air into the boiler through the brickwork. The power required to supply this pressure is only about 1 per cent. of the power generated. Pre-heating of the air for combustion is of considerable importance, for this promotes much more effective combustion, gives a higher flame temperature, and improves the heat exchange.

As regards corrosion, Mr. Hunter, who has studied the matter very closely, has found that in cases where gas-firing with Mond gas has been held responsible for damage to boiler tubes this damage has in reality been caused by improper proportions of gas and air, so that combustion in layers was taking place. Accordingly, while at one moment the flame would be of a decidedly oxidizing nature, at the next moment it might be of a reducing character. If gas is burned with a small excess of air, so that combustion takes place rapidly and is more or less complete before the products touch the boiler tubes, then no corrosion whatever can occur. Mr. Hunter suggests, therefore, that in firing water-tube boilers it is preferable to arrange the gas burner so that it points towards the floor at an angle of about 20 deg. below the horizontal, so that the gases may be completely burned before rising to the tubes. This also maintains the brickwork of the boiler upon which the flames play at a high temperature, and assists in the rapid combustion of the gas.

RESULTS WITH HIGH-GRADE GAS.

So far as the employment of a high-grade gas for steam raising is concerned, it is interesting, while dealing with the subject, to refer to results obtained at a works associated with the Hamburg Corporation water undertaking. A considerable supply of natural gas having been discovered in 1910, eleven miles from the city, in 1913, a main was laid from the source to the city gasworks, and since this date a mixture of coal-gas and natural gas has been used as a boiler fuel at the pumping station. Analysis of the natural product showed it to contain 97 per cent. of methane and to have a gross calorific power of 980 B.Th.U. In all, 24 modern boilers with superheaters have now been installed, the pressure of gas at the burner inlets being about 4 inches of water. In this instance the boilers are of the Lancashire type, the burners, inclined downwards at an angle of 5 deg., being pushed into openings through plates which cover in the furnace door spaces. The grates are covered with a bed of clinker, graded to about 1 inch lumps, which hinders the inflow of air and protects the firebars from the impinging flame. At the same time the whole installation has been arranged so that a change from gas to coal firing can be made if the occasion arises. For a period of two years, over which observations were taken, the boilers were heated, with only trifling interruptions, solely by gas, the volume consumed during this period being more than 450 million cubic feet. The average consumption of gas per horsepower hour was 25 cu. ft., as compared with an average for coal of 1.65 lb., and it is claimed that in this way the saving effected in the use of coal is about 7,000 tons per annum. At Hamburg combustion is considered satisfactory if the flue gases contain on an average not less than 7 per cent. of carbon dioxide.

That the development of gas-firing appliances is not altogether being left to the Continent and America is instanced by the new "Cumberland" burner, which is now to be found in use in a number of works in the North of England. This burner operates equally well on coke-oven, blast-furnace, or producer gas, and possesses the advantage of working satisfactorily under varying conditions of pressure, even when the latter falls so low as 0.5 in. water gauge. One of the prevailing faults with burners of this kind, that a back-firing occurs when the gas pressure falls, has been overcome in the Cumberland burner, which possesses the additional advantage of being readily cleaned without any interruption in worikng. Tests have shown that with this system the efficiency, with a high-grade gas having a calorific power of 540 B.Th.U. per cu. ft., is well over 75 per cent., the consumption being 2.75 cu. ft. per lb. of water evaporated.—*London Times Engineering Supplement.*

The Study of the Sediments as an Aid to the Earth Historian

(*Continued from page 183*)

recommend the thorough combing of the geological literature for material on the nature and origin of the sediments. But it is a fact, by no means sufficiently appreciated by most of us, that the amount of buried treasure of this kind is really enormous. A few years ago, while engaged in the study of phosphorite deposits, I was astonished to find that the papers published in France and England during the seventies contained a much clearer and more comprehensive interpretation of phosphatic deposits than could be found in any American text-book or reference work published since 1900. In fact, it was perfectly evident that most even of the more valuable of these foreign papers had never been seen by the authors of the compendia mentioned, nor even by Americans who had published important papers on the phosphatic rocks. I believe it is a fact that one of the greatest services that can be rendered, just now, to the advancement of our knowledge of sediments and sedimentary rocks would be the thorough investigation, digestion, and summarizing of what is already in print on the various types of sediments. It would vastly increase our effective working knowledge and might conceivably double it, for it must be clear that a fact or a theory which is lost is as useless as one that has never been found out.

Chemical analyses give much valuable information regarding sedimentary deposits. Not infrequently the general conditions of origin as well as the nature of the rock, can be inferred at once from the analysis. We have far too few of them, and it is one of the minor discouraging conditions of the study that even those we have are in many instances rendered useless by the omission of essential facts.

Furthermore, a great many analyses are published with only the most meager information regarding the source of the material. It is obviously of very little value to the sedimentationist to know that a certain analysis pertains to a Cretaceous shale from Mt. Diablo, California, because the mountain contains several distinct types of shales of Cretaceous age. In that case even the brief statement that it was a gray sandy shale with abundant fragmentary mollusks and echinoderms would greatly enhance the value of the analysis. The same benefit might be conferred by noting that the specimen came from a particular bed in a carefully described section already published. It is for this reason that the great number of analyses in Clarke's *Data of Geochemistry*, have only a small fraction of the value to the sedimentationist that they might just as well have had if the facts had been adequately stated. We need, therefore, more analyses, more comprehensive analyses, and especially more fully annotated analyses.

Probably our broadest, even if not our deepest, fund of information for the interpretation of sedimentary formations comes from the descriptions of sections by stratigraphers and by field geologists in general. Here, as in the case of the chemical analyses, the sedimentationist meets with frequent disappointment, simply because the exact and detailed observations, which alone could make the section valuable for his purposes, have been largely or entirely omitted. We have thousands of stratigraphic sections in which successive beds are described as "yellow sandstone," "gray shale," "fossiliferous limestone," etc., leaving the reader to guess as best he may the significant characteristics of the strata. Of course, the author of a report usually gives descriptions that are adequate for his own purposes even if not for those of others who may go to it for light. On the other hand those geologists who make it a practice to describe colors carefully, to note textures, the presence of cross-bedding, ripple-marks, sun-cracks, nodules, forms of grains, character of cements, nature, abundance, and distribution of fossils, to say nothing of mineral content, forms of large versus small grains, type and amplitude of cross-bedding and ripple-marks and the nature of the filling in sun-cracks, are a source of joy to the student of the sediments. Unwittingly perhaps, they are rendering us a valuable service. We only regret their scarcity.

Many of us are necessarily limited in the geographic range of our first-hand study of sediments and sedimentary processes. Others who have had the good fortune to visit distant regions, and especially the less known parts of the earth, such as the tropics and the arctic countries, can often with very little trouble collect observations and material which may later, in the hands of a trained student of sedimentation, yield important information for which we might otherwise have to wait for decades. The amount of such data now on hand in American universities and museums is very small when compared with that which is available for a study of volcanic rocks or fossil faunas.

These are some of the ways in which the study of the sediments and the sedimentary rocks can be forwarded not only by the special devotees of that branch of geology but also by anyone who takes an intelligent interest in the matter.

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